UNBOUND

Marine Engineering

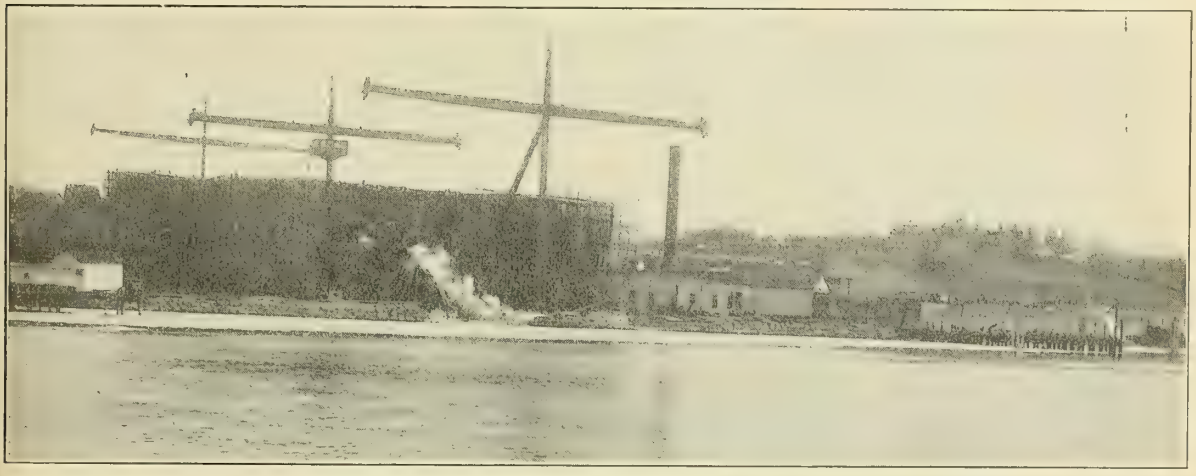
Vol. 7. NEW YORK, MARCH, 1902 No. 3

MAR 10 1902 PATENT OFFICE

THE EASTERN SHIPBUILDING COMPANY.

The closing years of the past century were made memorable in the annals of American industrial progress by an extraordinary increase in its business prosperity, stimulated, as it was to a great extent, by the wise and progressive policy of the general government and by demands growing out of the Spanish war.

Then came the disturbance in the East and its attending results in the rapid expansion of our commerce to the Orient. The outgrowth of the governmental policy of expansion and its accompanying improvement in its naval strength is found in the fact that several large establishments for the building of vessels have sprung up of late, and American shipping and shipbuilding has been given an impetus which savors of dawning prosperity and a rapid increase in our commercial marine. Old shipbuilding establishments have found themselves congested with orders for either the government or private parties, and new plants have been erected at various points of commanding advantage, ready to take their share of the increased business. We are now at a period when our merchant marine must improve the opportunity and increase its transportation facilities.



THE WORKS OF THE EASTERN SHIPBUILDING COMPANY FROM THE THAMES RIVER.

Some of our great railway corporations immediately laid plains responding to the demands of a rapidly increasing business prosperity. They began seriously considering what must be done to protect their interests. It required but little time for these shrewd and far-seeing railroad managers to reach conclusions; they had been thoroughly schooled by an experience suited to the task. Among the first and most aggressive of these corporations to take action was the Great Northern Railway Company, of St. Paul, through its president, James J. Hill. Figuratively speaking, Mr. Hill is a man who "never slumbers nor sleeps," ever watchful, ever wakeful to the vital demands of his business interests.

In the natural course of business Mr. Hill had become acquainted with Mr. Hanscom, then general superintendent of the Bath Iron Works, Bath, Me. In Mr. Hanscom was found the man needed for the furtherance of these plans for increasing the transportation facilities of the Great Northern Railway Company, and in due time a contract was agreed upon for the construction of the two largest freight and passenger steamships ever built in the world, involving an expenditure of $5,000,000.

Then followed the organization of the Eastern Shipbuilding Company, consisting of Mr. C. W. Morse, of New York, Mr. Hanscom and a few other prominent business men, and the location of the present shipbuilding plant. Mr. Hanscom, together with the naval architect and engineer of the company, Mr. W. A. Fairburn, visited various localities along the Atlantic coast, and finally determined upon the present site of the Eastern Shipbuilding Company, at Groton, opposite New London, Conn., on the banks of the Thames. The site selected was formerly used by the New York and Providence Railroad as a ferry terminal before the drawbridge across the Thames was built.

In the summer of 1900 work was begun in laying out the yard, and at the same time temporary offices and a drafting room were secured. Plans were prepared for the monster vessels under contract, and the work pushed forward with dispatch. Contracts for material

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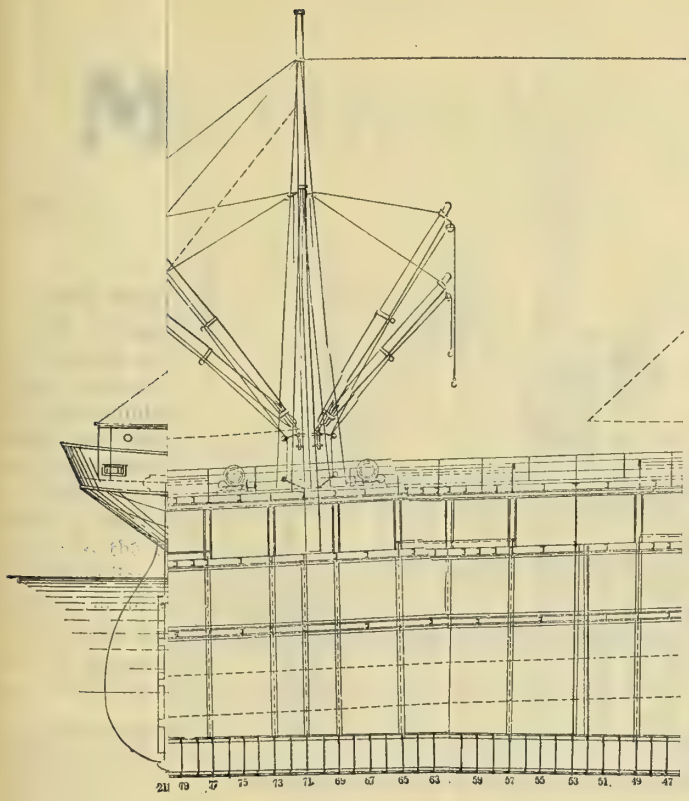
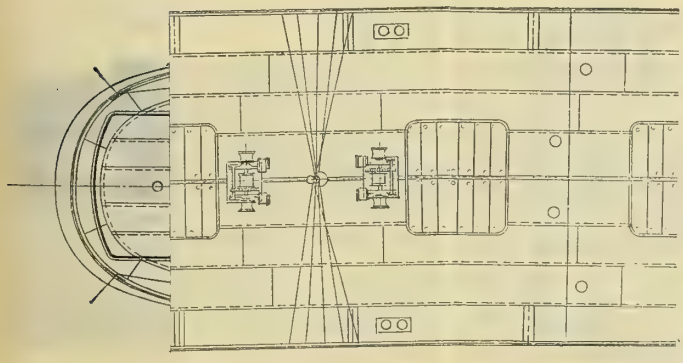
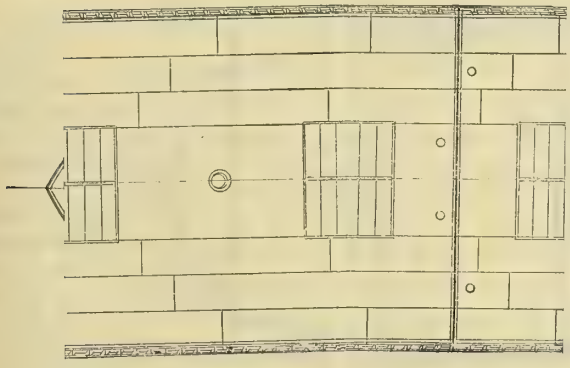
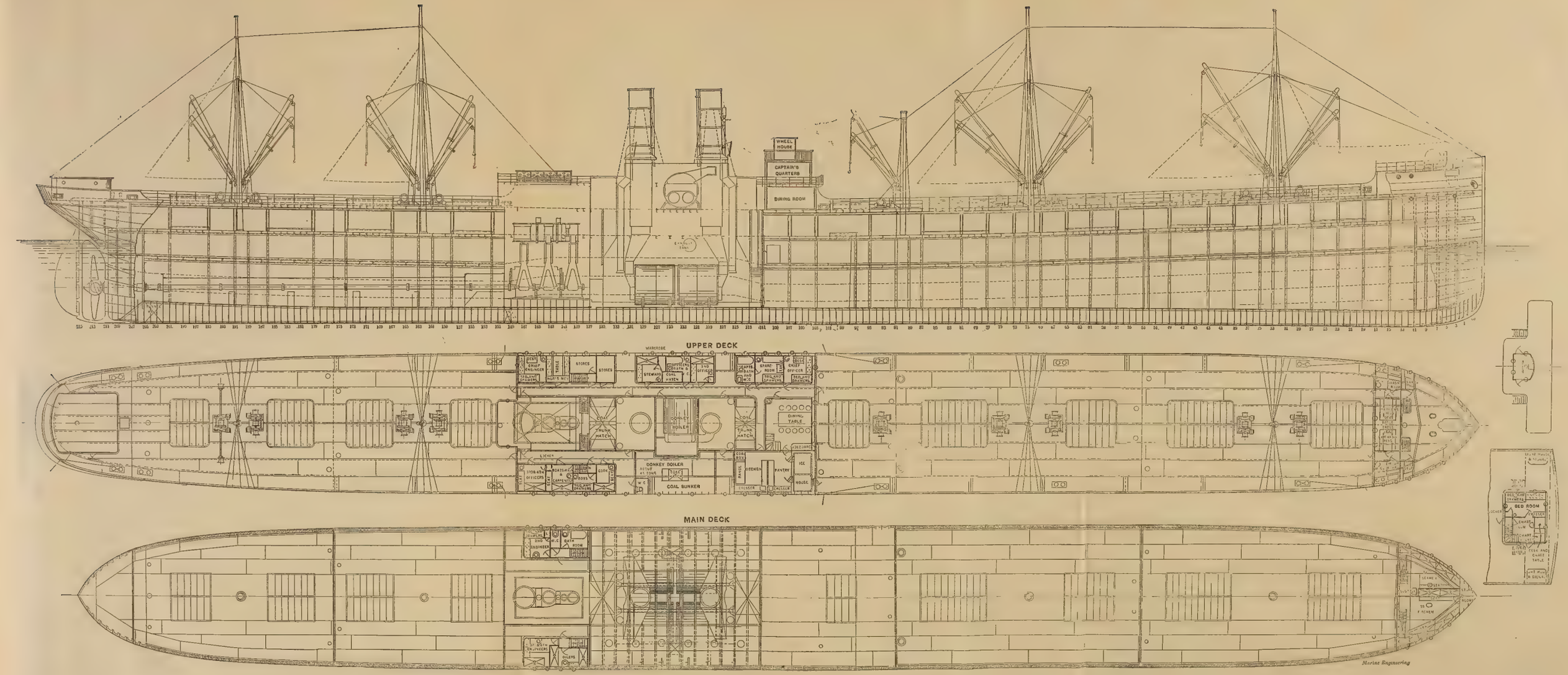




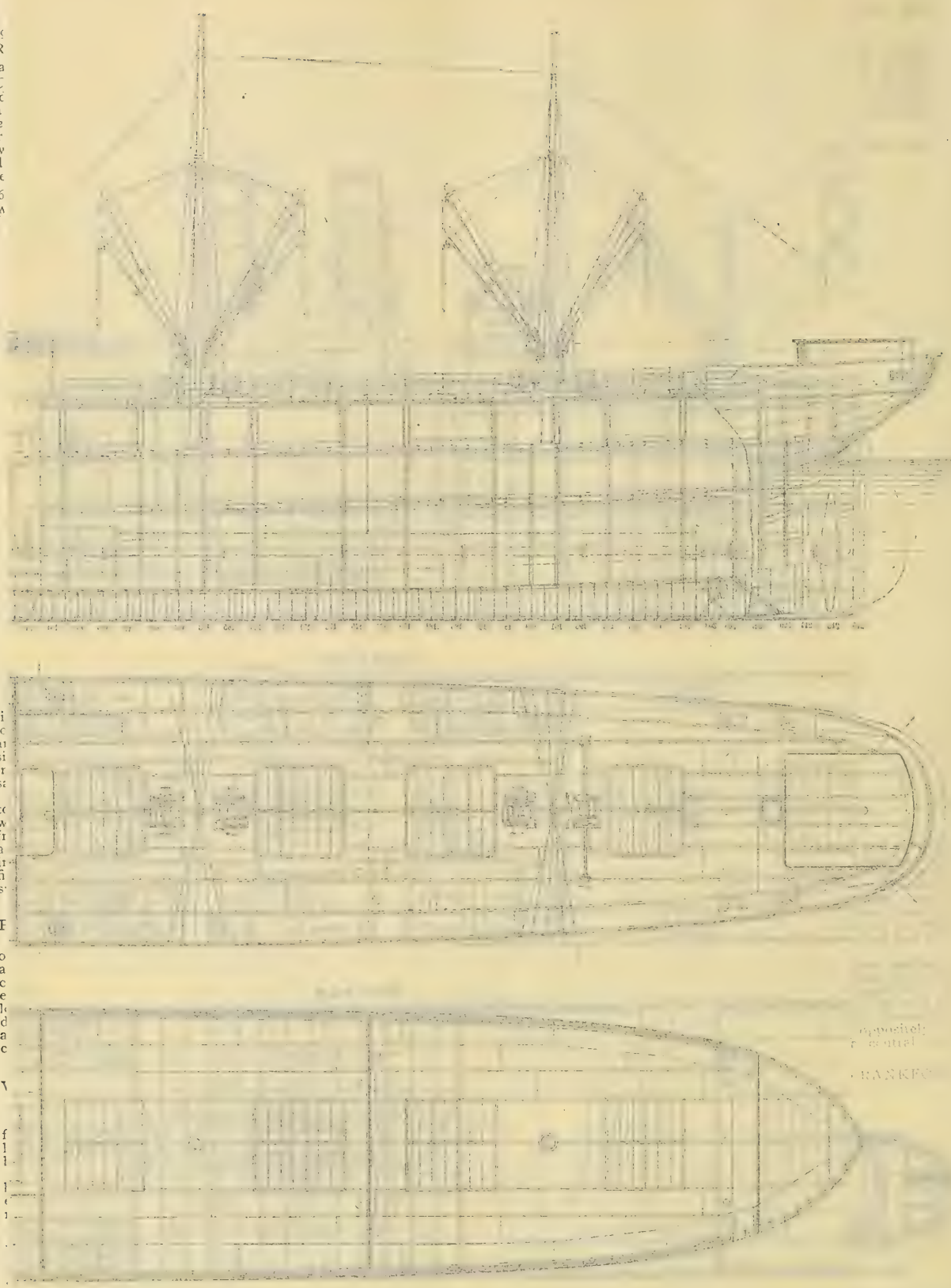


LONGITU[illegible]F THE AMERICAN [illegible]PBUILDING CO[illegible]



LONGITUDINAL AND DECK PLANS OF THE OCEAN FREIGHT STEAMERS MINNETONKA AND MINNEWASKA, BUILT AT THE CLEVELAND YARDS OF THE AMERICAN SHIPBUILDING CO. FOR THE AMERICAN NAVIGATION CO. OF NEW YORK.

FOR DESCRIPTION SEE PAGE 185.



LONGITUDINAL AND DECK PLANS OF THE OCEAN FREIGHT STEAMERS MINI

and supplies were placed at an early date and to an amount rarely heard of in shipbuilding. From this time on the work of building the plant and the ships has been carried on simultaneously.

The advantages of location are many and very important, among which may be noted the extensive water-front of over one-half mile, ample depth of water at all tides, direct railroad communication to all points east and west, pleasant, good working climate, and approximate nearness to markets for all classes of supplies.

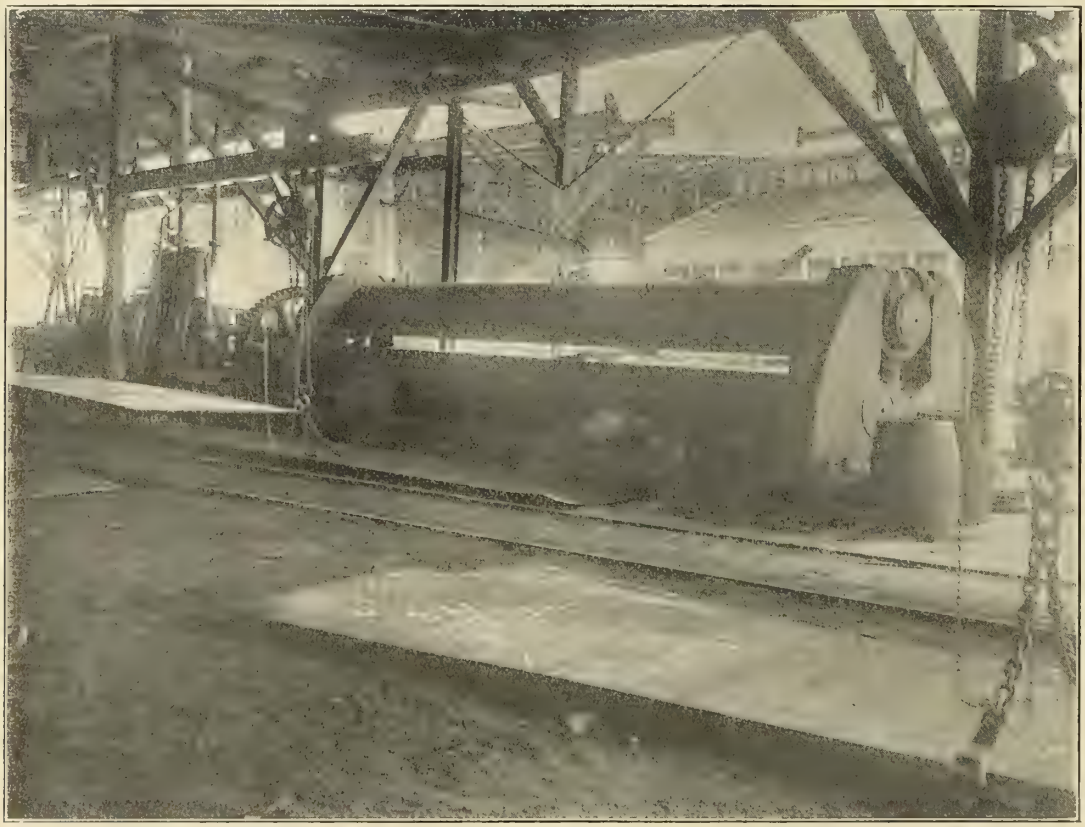
Entering the yard by the railroad track from the south, for over a thousand feet the land is used for storing material. The extent of space required will be realized by the fact that in the steel work of the two hulls now undergoing construction there are about 28,000 tons of steel.

The material is unloaded and stored by locomotive cranes having a sweep of 80 feet. The plates are then laid off from template, loaded upon cars by the cranes and run down the yard to the ship sheds.

As we proceed northward the first building to the right contains the carpenter and joinery shops, with a mold loft above. Farther on are the machine, pipe and sheet iron shops. Opposite to these buildings, on the banks of the river, is the plate shop. North of the plate shop are the engine and boiler rooms, bending slabs, furnaces and forges. Immediately beyond and extending across the yard in an east and west direction are the ship ways. The general layout of the yard is shown in the illustrations on pages 99 and 100 taken from recent photographs. Let us now inspect the various buildings above mentioned.

At the south end of the plate shop, and opening directly into it, is the new laying out shed of 100 by 60 feet, which is equipped throughout with jib cranes. The locomotive cranes can also enter this shop, and overhead is a heavily timbered storeroom for electrical equipment and electric workshop.

The punch shed, or plate shop, built of heavy timbers, is a well-lighted building, 300 feet long by 80 feet wide, and here are found the heaviest and largest machines used for plate and shape work. There are in all twenty-five large tools in this shed, arranged in three lines, and driven from one overhead main line of shafting running down the center of the shop. The tools for the angles are on the east or open side of the building, and include horizontal punches, angle shears, etc. In this line are also three sets of rolls. The largest set, which is run by a double steam engine, is built by Hilles and Jones, can handle 26-foot plate, and may also be used for flanging. This machine weighs 100 tons. Adjoining are the straightening rolls and the mast rolls, both of which are belt driven from the main shaft. The shears and punches down the center of the building are of the heaviest pattern, and most of them are built by the Hilles and Jones Company. The largest punch is of 60-inch throat, can punch a 2-inch hole through a 1 1-4 inch plate, and weighs 30 tons net. The capacity of this shop is 2,000 tons of steel machined in one month of ten-hour working days.



TWENTY-SIX FOOT BENDING ROLLS.

Along the rear of this shop are two pairs of double radial countersink drills made by the Prentiss Machine Company, a 30-foot planer of 25 tons weight for planing the edges of plates up to 1 3-8 inches, and a compound scarfing machine and butt planer, which was designed by the Eastern Shipbuilding Company and made by the Builders' Iron Foundry. This is a novel machine, and has proved very efficient in service. It has a capacity for planing the edges of steel plates 8 feet wide and 1 1-4 inches thick, and for milling two scarfs, 6 1-2 inches wide by 16 inches long, at the same time. The planing mechanism is of the usual type, the plate being clamped to the table by a series of jack screws bearing against a stiffed bow girder. The scarfing mechanism is of the milling machine type, and is made very heavy to avoid chattering. The spindles are 3 1-2 inches diameter and made of high grade open-hearth steel, carefully fitted to bronze line bearings, adjustable for wear. These spindles are not vertical, but are set perpendicular to the scarfed surfaces. The milling heads are clamped to the gun iron girder of the machine. Horizontal feed takes place at the ends where the housings are simultaneously moved by screws, which are positively driven from the same shaft that drives the spindles. The spindles are given a slow vertical feed, which combines with the horizontal feed in such a way as to result in a strictly diagonal movement at the desired angles. The total weight of

PLATE PLANER.

VIEW LOOKING INTO PLATE SHOP AND DOWN THE YARD—JOINER SHOP AND MOLD LOFT TO THE LEFT.

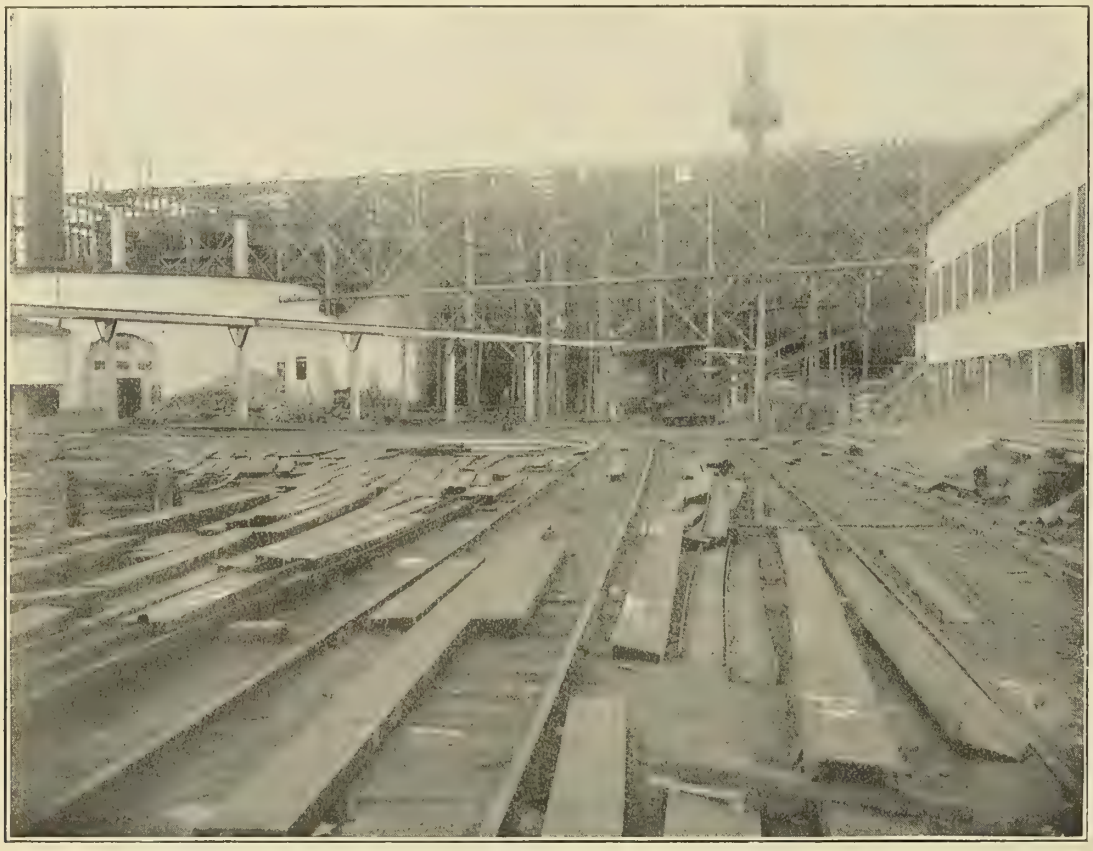
the machine is 9 tons, and it is well designed, with metal judiciously arranged to resist the stresses which are met with in machinery of this class.

Over each of the machines in this shop is a jib crane; those used for serving the countersinks and planers are of wood, with iron braces and stepped on the floor, but all the others are of steel stepped on the machines themselves and guyed from the girders in the roof trusses. These latter cranes are made of special section to meet the requirements of each machine. All the cranes are fitted with under-hoistings.

Adjoining the north end of the plate shed is the power house for driving the machinery and compressing the air for the pneumatic tools. An Erie engine of 175-horse power, running at 225 revolutions, drives the line shafting in the plate shed. There are two compound steam and air piston intake compressors built by the Ingersoll-Sargeant Company which have intercoolers and superheaters and deliver the air at 100 pounds pressure. The capacity of the small machine is about 1,500 cubic feet of free air per minute, and that of the larger machine about 2,000 cubic feeet. A Wheeler condenser with 3,000 square feet of tube cooling surface is mounted over a Blake compound air and circulating pump and receives the exhaust steam from the entire plant.

The compressed air from the compressors in the engine room is led to two vertical cylindrical receivers at the after end of the shipbuilding berths through an 8-inch pipe, and from here is distributed through several mains running the length of the berths. From these it is tapped into rubber hose leading to headers and then distributed to the different tools. Pneumatic riveting has been used almost exclusively in all ship construction work at this yard.

To the north of the engine house is a large brick building containing the bending slabs and furnaces, the blacksmith shop and the boiler house. The shapes may be drawn on skids to the bending floor from the angle shop by means of an electric winch. The maximum length of the bending slabs is 80 feet and the width 50 feet. There are two steel plate bricked furnaces, one of which will take a plate 30 feet by 8 feet, and the other will heat shapes up to 80 feet in length.

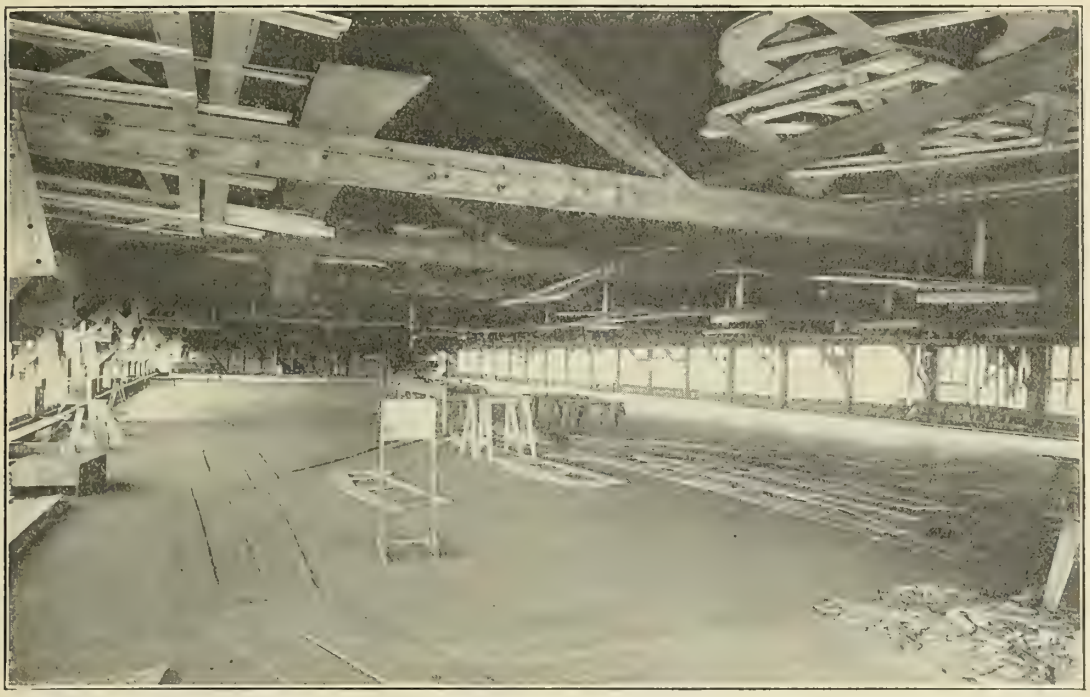


VIEW OF THE SHIPS, LOOKING UP THE YARD.

The blacksmith shop contains a large number of well arranged forges and two steam hammers. The air blast is supplied by a blower driven by a 35 horse power motor. The battery of four Erie fire-tube boilers furnishes steam at 125 pounds pressure, and is of 1,000 horse power capacity. Coal is conveyed from a large bin on the water front to the boilers by an overhead trolley. A coal wharf with run and derricks leads direct from deep water river frontage to the coal bin.

A large Worthington underwriters fire pump is used for fire protection, and maintains a pressure of 60 pounds in the mains which lead to several hydrants efficiently located in the yard.

Plates which are ready for the ship are carried from



MOLD LOFT.

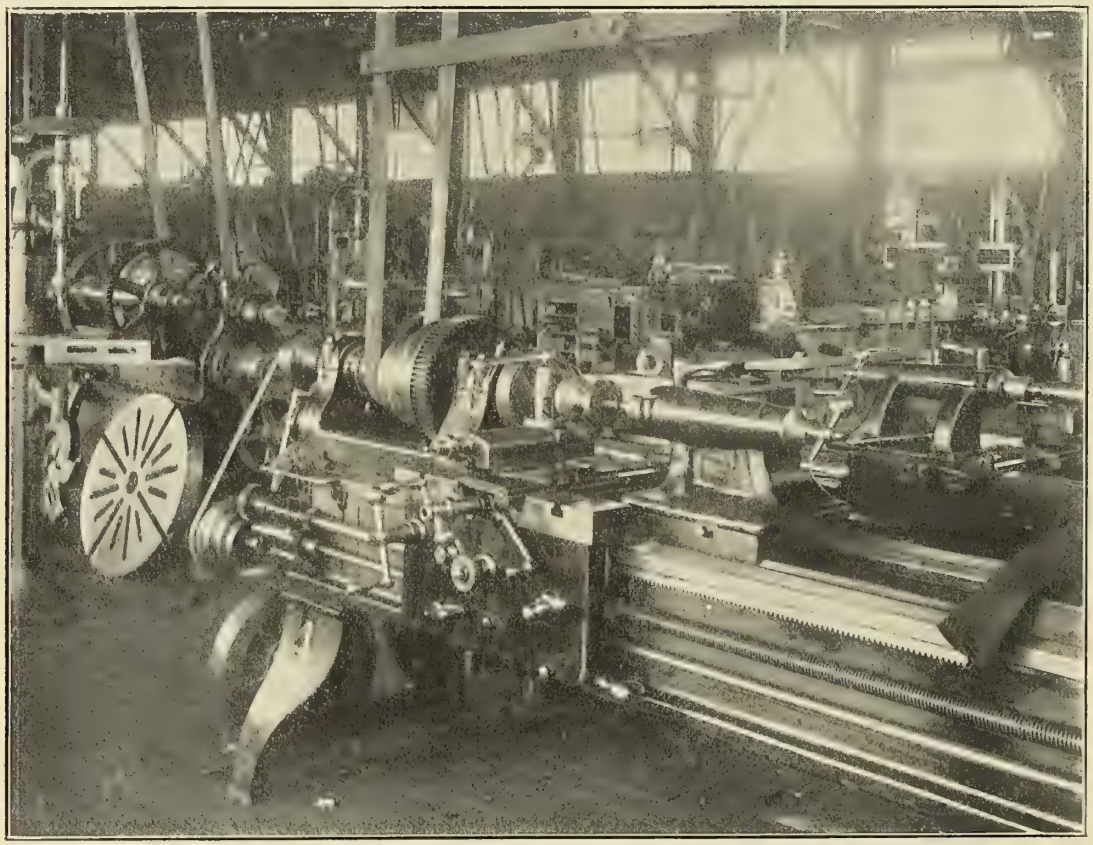
PIPE AND SHEET METAL SHOPS.

the plate shop on a double overhead conveyor, shown in the engraving on page 101, to the building ways, where they are picked up by the novel overhead wire rope trolley system and delivered in place on the ships.

Retracing our steps, however, across the central open space of the yard we will visit the remaining buildings to the east of the railroad tracks. The pipe and sheet iron shop, machine shop, mold loft and joiner shops are built at the east side of the railroad track. The nearest of these, the pipe shop, contains the usual pipe, sheet iron, lead, brass and copper tools. At present the only work for the machine shop is in finishing up the ship fittings and making the necessary repairs and improvements about the plant. A 350-horse power Erie engine drives the machinery for these shops, as well as the joiner shop, and also runs the dynamo used for electric power This latter is of 150 kilowatt capacity, and supplies the current at 250 volts. The machinery equipment was furnished by Hill, Clark and Company, Niles Tool Works, Jones and Lamson Machinery Company, Hilles and Jones, Manning, Maxwell and Moore and other makers and comprises several types and sizes of lathes, planers, drills, shears, grinders, milling machines, etc.

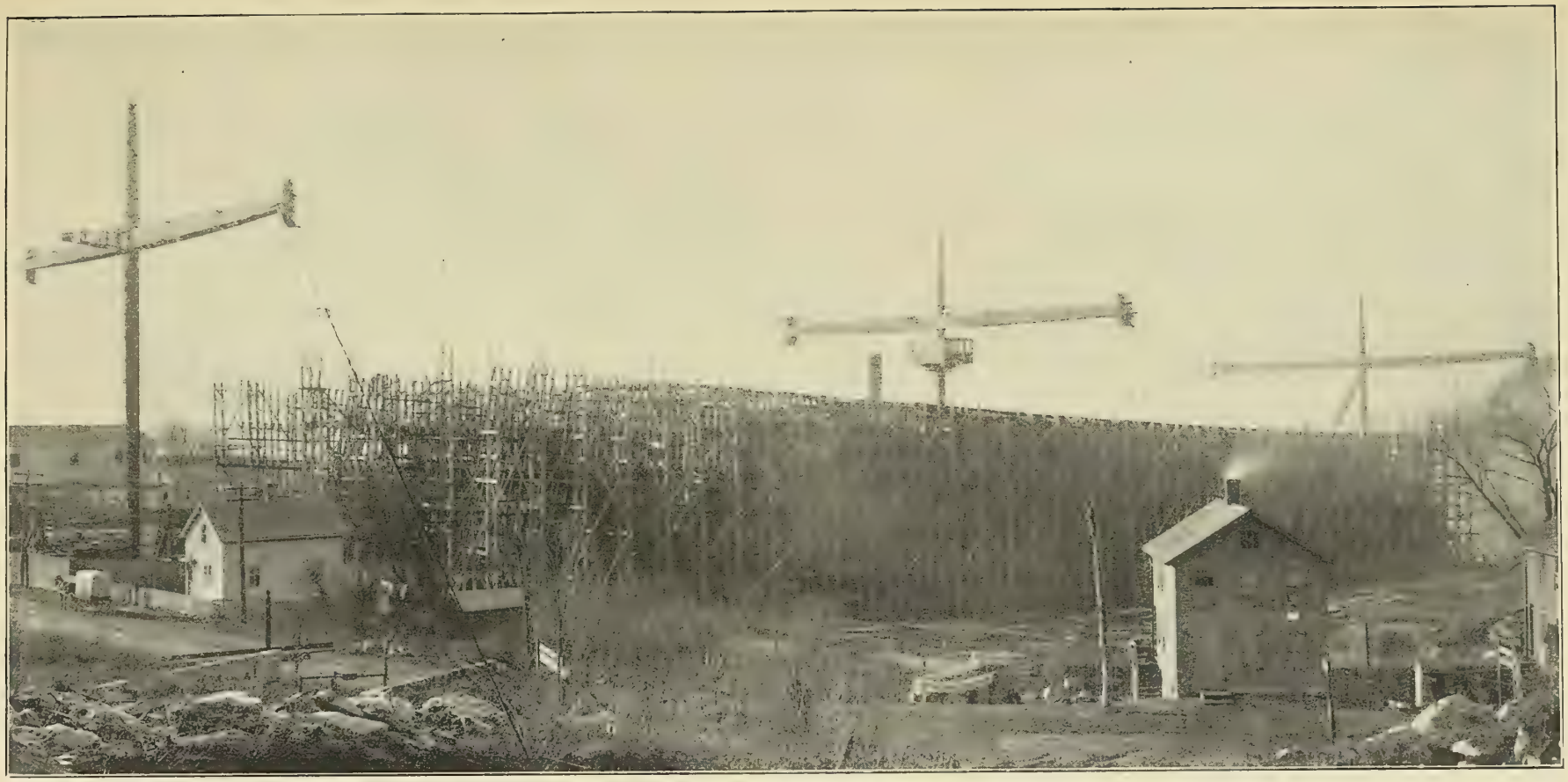
South of this shop are the temporary offices, 30 by 70 feet. On the main floor are the general offices, and above are the drafting rooms, divided into the hull, engine and scientific departments. All plans for the construction of the ships were gotten out here. Extending to the south are the joiner and machine shops and mold loft above mentioned. The former is located on the first floor and well equipped with first-class woodworking machinery. Most of the joiner work for the two ships has already been turned out. The mold loft floor above is built very substantially, and is laid on heavy timbers in two strakes of selected dried white pine. The floor is 250 by 70 feet, and here the full size body plan and lines were laid down. As these ships are of such great length, the midship section could be carried for a distance of over 150 feet and still leave sufficient length for a fine entrance and run.

In carrying out the details of construction templates were made for each frame, and longitudinal, and wherever possible the universal system was used for laying out the plating. By this system most of the deck and bulkhead plating is made of a standard size, with standard rivet spacing, such that a plate can be placed in almost any location on the deck or bulkhead. This system, which is extensively used on the Great Lakes, reduces greatly the time occupied in construction, and results in rapid and better as well as cheaper work.



MACHINE SHOP.

Returning to the shipbuilding berths where the ships have now assumed definite shape, we note an important feature in the equipment of this plant, which is the trolley system for conveying the material over the shipbuilding slips. Economy in large ship construction nowadays depends largely upon the shipyard facilities for handling material, and the essential points in such



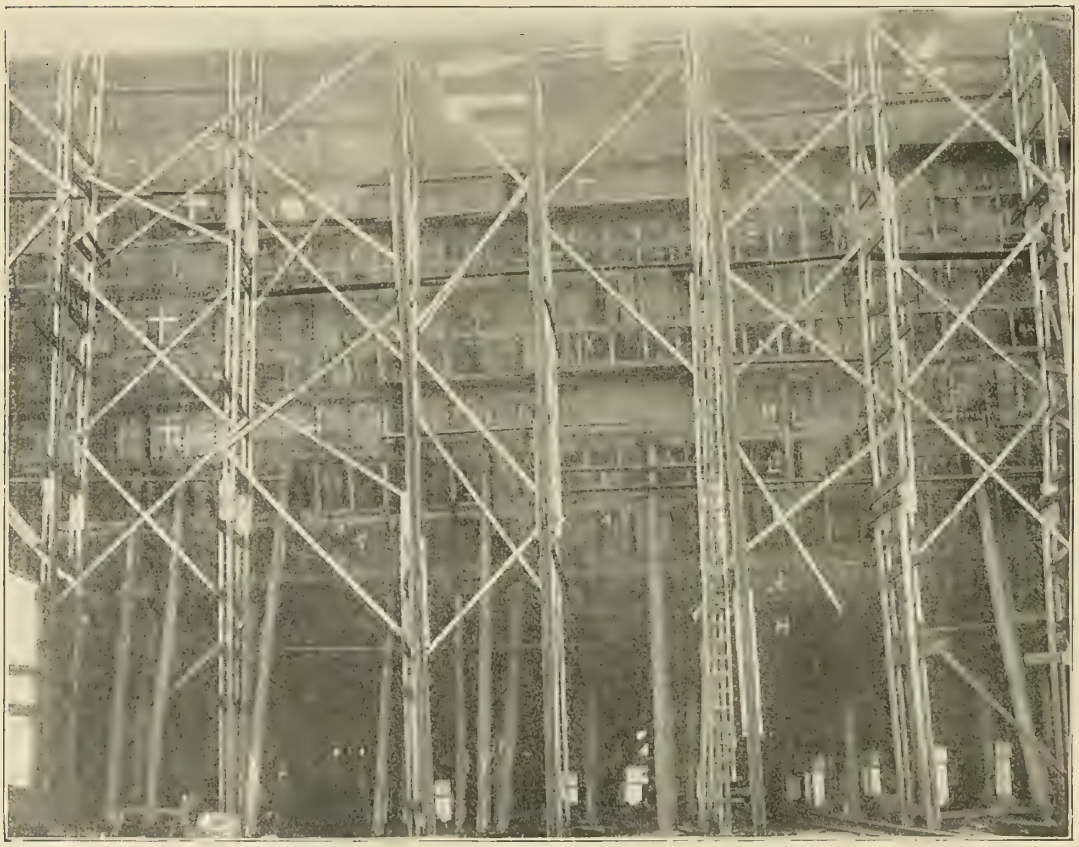
VIEW OF THE SHIPS AND THE OVERHEAD TROLLEY SYSTEM AT THE WORKS OF THE EASTERN SHIPBUILDING COMPANY.

a system must be, complete immunity from accidents, and a simple and rapid arrangement for hoisting and distributing where desired to any part of the vessel any plate or member entering into the construction of such a vessel. Speed of operating is of course an essential feature.

The trolley system installed at this yard was designed by President Hanscom, and is an enlargement of simpler methods installed by him in establishments with which he has formerly been connected. This system, which is shown in the engraving above, consists of three vertical masts erected between the ships, one at the bow, one at the stern and the third or central midway between the other two. These masts are about 140 feet high from foot to cap, and rest upon immense foundations. To each mast is fixed a large horizontal yard 170 feet long, built of rectangular section as light as consistent with the required strength. These yards are elevated 90 feet from the ground and at sufficient height to allow the plates and beams to clear the hulls now building and to be carried readily to the desired place.

The masts are securely stayed in the fore and aft directions by strong steel wire stays and guys securely anchored in rock. In addition to the water-end stay the after mast is held in position by a steel strut or compression strong back. Steadiness in an athwart-

JOINER SHOP.



VIEW OF THE SIDE OF A SHIP.

ship direction is obtained by steel guys similar to those forward and aft, running from the ends of the yards, and these are also securely anchored in rock. A strong fore and aft steel wire stay connects the end and middle of each yard, and diagonal wire rope guys run from the ends of each yard to each mast. The yards are supported from the masthead by large steel wire guys or lifts, and the two end yards are well braced and trussed with heavy wire rope tension guys. The working field of the trolleys is a large rectangle, 600 by 175 feet, supported over the vessels and securely held in position by masts and guys.

Material can be carried to any position in the rectangular field by means of fore and aft traveling carriages on thwartship moving cables suspended between cars running on tracks on top of the yards. The motion to the cars and carriages is obtained from electrically operated machinery, which was also built and designed by the Eastern Shipbuilding Company.

One of the strong points of this system is the speed at which the trolleys are operated. A load can be hoisted in ten seconds, the carriages in the tracks on the yard-arms move the cableway the complete length of the yard in thirty seconds, and the trolley carriage travels the length of the cableway in twenty-five seconds, all with full designed working load. The two trolleys have hoisted and put in position over 100 tons in a working day of ten hours.

This system possesses many advantages, the principal one of which is the very large number of usages to which the framework and guys of the structure can be placed. Such a system could be designed to take any number of traveling trolleys, each one having transverse and longitudinal motion, whereas other systems confine the number of hoists made at the same time to one or two.

The equipment is at present in successful operation at New London, and is fitted with ten traveling trolleys capable of working simultaneously.

When Professor Von Halle, of Germany, recently visited the New London yard he remarked that, "The overhead trolley system of handling material at the works of the Eastern Shipbuilding Company is the greatest feature of the most remarkable shipyard in the world."

Fast Motor Launch.—A French built boat, *Rollo V*, according to *La Locomotion Automobile*, has made extraordinary speed on many occasions. The boat has a 24 horse power gasolene engine, built by Panchard and Levessor, Paris. The hull is 39 feet 3 inches long and 4 feet 3 inches in beam. She is built of light and rigid construction and planked with three sheetings of cedar. This little boat has been increasing her speed since April 21st, when 14.9 miles were made at a speed of 11.5 miles per hour, to a speed over the same course in June last of 15.7 miles per hour.

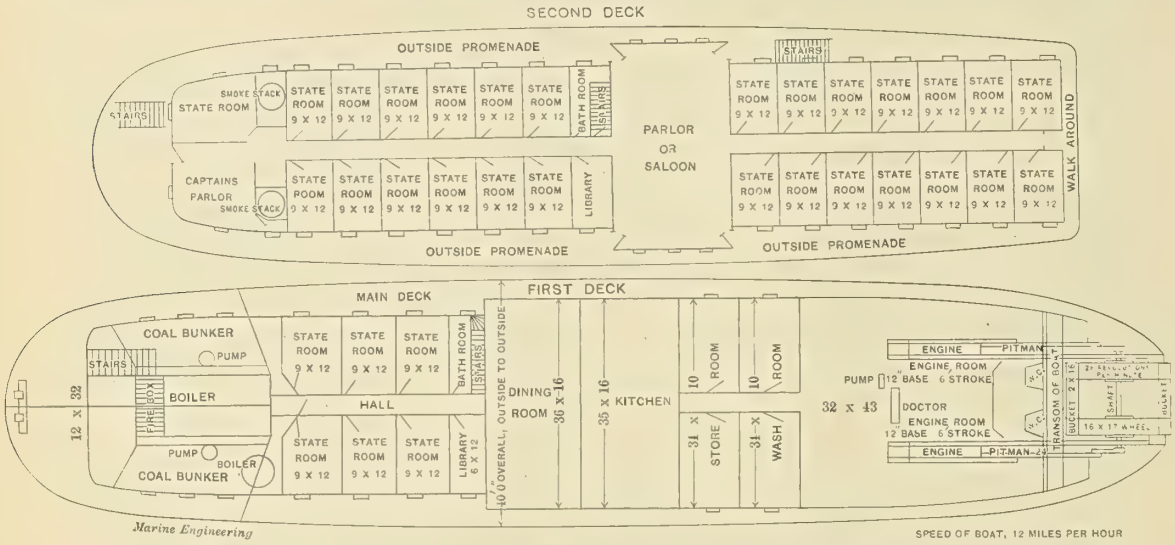
MISSISSIPPI RIVER MISSION BOAT MEGIDDO.

Mission Boat on the Mississippi.

A boat to fill a peculiar trade has recently been completed by M. J. Godfrey, of Lyons, Ia. The vessel which, is called the *Megiddo*, which interpreted means, "The Lord is in His place with an army," is to be used by the Association of Christian Brethren for mission work along the Mississippi. The *Megiddo* is of the usual style of western river boat with a large stern wheel, and has accommodations on board for taking care of 100 people. The accompanying deck plans show an admirable arrangement for this speciai service.

The hull is 175 feet long by 32 1-2 feet broad on the bottom, 36 feet on the deck and 40 feet over the guards, and is built from the best selected white oak posts from Virginia and Missouri. The fir used in the construction is from Washington, the pine from Maine, the hard pine from Georgia and the other hard wood from Wisconsin. On the main deck, aft of the forecastle, are the boiler-room, with coal bunkers, six staterooms, bathrooms, then a dining-room, kitchen, pantry, two storerooms and large engine-room. On the second deck are stairs and companion way, a large

captain's parlor and bedroom, and twelve staterooms and a ladies' parlor. Aft of this are fourteen staterooms. Above is the Texas with four staterooms, and on top of all is the square pilot house. The forecastle is screened off with shutters in bad weather. The engines and boilers are built by the Star Boiler Works, of Clinton, Iowa. The boiler is of the locomotive type, with shell 52 inches in diameter, 20 feet long over all, and with sixty-eight 3-inch tubes. There is also a 12-horse power donkey boiler for supplying steam heat. There are two high pressure engines, one mounted on either side of the vessel and driving the stern wheel, which is 17 feet in diameter with sixteen buckets 24 inches by 16 feet long. Each cylinder is 12 inches diameter by 6 feet stroke, and is fitted with California cut-off and balance valves. The usual "Doctor" is used for boiler supply and bilge pump, and there is one Gardner duplex pump and two deck pumps. The vessel is heated throughout with steam, and is lighted by acetylene gas.



DECK PLANS OF MISSISSIPPI RIVER STEAMBOAT MEGIDDO.

Trial of the Japanese Destroyer Kasumi.

The Japanese torpedo-boat destroyer *Kasumi*, built by Yarrow and Company, Ltd., Poplar, England, recently completed her official trial and attained the average speed of more than 31 knots over the measured mile. The vessel was launched on January 23, 1902, was taken on preliminary trial January 24th, and successfully completed the official trial on January 29th. This record of completing the trials within a week of the launching of the vessel speaks of the high class of work of this firm, and their extensive experience in this special line.

The official trial consisted of three hours continuous run, with a load of 40 tons on board, the speed being ascertained by six runs over the measured mile. The following is the record of these six runs.

Run.	Hour.	Air pressure in Stokehold.	Revolutions per minute.	Time.	Speed.	First Mean.	Second Mean.	Admiralty Mean.
	A. M.	IN.		M. S.				
1	11 13	.6	395.8	2 40	29.032	30.969		
2	11 24	.93	392.1	1 49.4	32.906	30.795	30.882	
3	11 33	.9	390.3	2 5.5	28.685	31.087	30.941	31.075 Knots on Measured Mile.
4	11 43	1.1	396.8	1 47.5	33.488	31.236	31.161	
5	11 54	1.1	398.1	2 4.2	28.985	31.394	31.315	
6	12 3	1.2	401.7	1 46.5	33.802			

After the six runs were made, to ascertain the advance per revolution of the screw, a three hours' trial was proceeded with, with the result that a mean speed during the three hours of 31.245 knots was obtained.

The American Shipbuilder has come out with a new dress of type improving quite materially the appearance of this well-known weekly.

Yarrow Water Tube Boilers.—The Austrian naval authorities have decided to adopt Yarrow Water Tube Boilers in the three battleships about to be laid down.

THE THEORETICAL AND PRACTICAL METHODS OF BALANCING MARINE ENGINES, II.*

BY NAVAL CONSTRUCTOR D. W. TAYLOR, U. S. N.

A Comprehensive Abstract of the Prize Paper Presented Before the Society of Naval Architects and Marine Engineers, November, 1901.

27. In this paragraph the author discusses the possibilities of balance with four cranks. The mathematical analysis is given in appendix C. The results of the investigation applied to 256 cases, spread over the ordinary range of proportions, are shown graphically in a large diagram not here reproduced. In this investigation the four cylinders are denoted by the numbers 1, 2, 3, 4, No. 1 being aft. The reciprocating weights are similarly denoted by w_1, w_2, w_3, w_4, the latter being considered as constant and equal to unity. The spacings of the cylinders from No. 1 are expressed in terms of the length of the engine taken as unity.

The chief features of importance in this diagram are summarized by the author as follows:—

From a study of this diagram, which covers the whole field of four-crank balance, we can readily determine that portion of the field worthy of final detailed investigation.

It will be observed in the first place, that where the crank angles are such as to give an evidently inferior turning moment, the resultant secondary force is usually large, and the relative reciprocating weights such as would be very difficult to obtain in practice.

In the second place, for arrangements where w_2 and w_3 range from 1 to 1.5, the secondary forces are not large, the crank angles approach reasonably close to those which we have seen give the most uniform turning moment, and w_1 does not differ greatly from w_4, which is assumed always as constant and equal to unity.

In the third place, the secondary force varies greatly, both in direction and magnitude, while the secondary moment varies comparatively little, indicating that while we may expect, by further manipulation of weights and angles, to eliminate secondary force, it will not be possible in practice to eliminate thus the secondary moment.

The obvious inference from the results shown in this diagram is that we need examine in detail only arrangements where cylinder No. 4, having unit reciprocating weight and zero crank angle:—

Cylinder No. 3 has reciprocating weight somewhere in the neighborhood of 1.5, and its crank angle in the second quadrant, ranging approximately from 135 to 160 degrees.

Cylinder No. 2 has reciprocating weight somewhere between 1 and 2, and its crank angle in the third quadrant and somewhat less than 270 degrees.

Cylinder No. 1 has reciprocating weight somewhere in the neighborhood of 1, and crank angle in the first quadrant, ranging, approximately, from 45 to 60 degrees.

MOST COMPLETE BALANCE ATTAINABLE WITH FOUR CRANKS.

28. As it is not to be expected that we shall be able to get rid of both secondary force and secondary moment by futher manipulation of weights and crank angles for four cranks, the next step in my investigation will be directed toward the determining of combinations where secondary forces, as well as primary forces and moments, are extinguished, and the resulting unbalanced secondary moment known.

In Appendix C will be found detailed the graphic methods followed, and their results are shown in diagrams A to G, which enable us to determine absolutely the crank angles and relative reciprocating weights for a four-crank engine, with any practicable cylinder spacing, for which primary and secondary forces and primary moments are extinguished. Such engines are upon the Yarrow, Schlick, and Tweedy system, and have been much used abroad, it is claimed, with great success. It is seen that the cylinder axes once located, the crank angles and relative weights follow, and are readily determined by simple inspection from diagrams A to F. While theoretically any order for the cylinders may be chosen, in practice, owing to the fact that the lightest weights must be on the end cranks, and that uniform turning moments are desirable, it is advisable to adopt the general arrangements outlined below.

For four-cylinder triple expansion engines the two low pressure cylinders should be outside, and their moving part should be as light as possible. Each low pressure cylinder does only about half the work of the high pressure or medium pressure, and it is desirable to have the low pressure connecting rods, crank pins, etc., reduced in due proportion.

For four-cylinder quadruple expansion engines the high pressure and M^1P. cylinders should be outside and the M^2P. and low pressure inside. Care must be taken to design the low pressure piston as light as practicable, and it is advisable to have the air pump, if worked by a lever, driven from the low pressure crosshead, as thus the low pressure reciprocating parts are virtually lightened.

It is advisable to have the forward pair of cylinders as close together as practicable, and the after pair also as close together as practicable. This result is facilitated if the valves for the two outer cylinders high pressure and M^1P. are placed at the ends of the engine, and the valves for the two inner cylinders M^2P. and low pressure in the middle.

Balance can be had without the precautions noted above, but with much greater additions of weights than would otherwise be needed.

REVOLVING BALANCE FOR FOUR CRANKS.

29. With a four-crank engine, balanced as regards the reciprocating weights, there are so many ways of obtaining revolving balance that it becomes a question of selecting that one having most practical advantages as regards simplicity and cheapness. The ideal method as regards balance alone is to fit proper counter-balance weights opposite each crank. If, however, the revolving force and moment polygons are plotted, it will be found that equally complete balance can be secured with less total addition of weight. If moments are taken about the after crank as usual, a revolving weight at the forward crank at a suitable angle will close the revolving moment polygon. This will, of course, mean an additional side to the revolving force polygon, but the latter can now be closed

*Continued from February number, page 66.

by a suitable weight at the proper angle at the after crank. In practice it is not convenient, as a rule, to apply balance weights at the cranks, unless they are on or opposite to the crank. So the most feasible plan in practice is to fit two revolving counter-balance weights, one aft of the engine framing and the other forward. The turning wheel can usually be made use of for the attachment of one of these weights, and if the forward end of the shaft is extended two or three inches, a wheel or disk for a forward balance weight is readily attached. Once the correct force and moment polygons are plotted, the amounts and angles of these weights are readily determined.

Before finally balancing revolving weights it is well to take advantage of any obvious methods for reducing the unbalanced resultants. This may often be done, for instance, by drilling holes in one or more solid crank pins, or filling one or more, when they are hollow, with lead or similar devices. The force and moment polygons will always show what is wanted and indicate the direction along which to work.

ENGINES WITH FIVE CRANKS.

30. It is not necessary to enter into a detailed analysis of the case of five-crank engines. With them perfect balance can be secured in a very simple manner.

We have seen that with three-crank engines, with cranks equally weighted and spaced, both primary and secondary forces are balanced. The balance, as regards forces, is even more complete than this. I have, throughout, taken the acceleration of reciprocating parts as proportioned to

$$\cos\theta + \frac{\cos 2\theta}{n}.$$

MacAlpine has shown that an even closer approximation is given by taking the acceleration as proportional to

$$\cos\theta + \cos 2\theta\left\{\frac{1}{n} + \frac{1}{4}\cdot\frac{1}{n^3} + \frac{15}{128n^5} \div \dots\right\}$$

$$-\cos 4\theta\left\{\frac{1}{4n^3} + \frac{3}{16n^5} + \dots\right\} + \cos 6\theta\left\{\frac{9}{128n^5} + \dots\right\}.$$

Now, with a three-crank engine, with cranks equally weighted and spaced, the resultant force due to terms

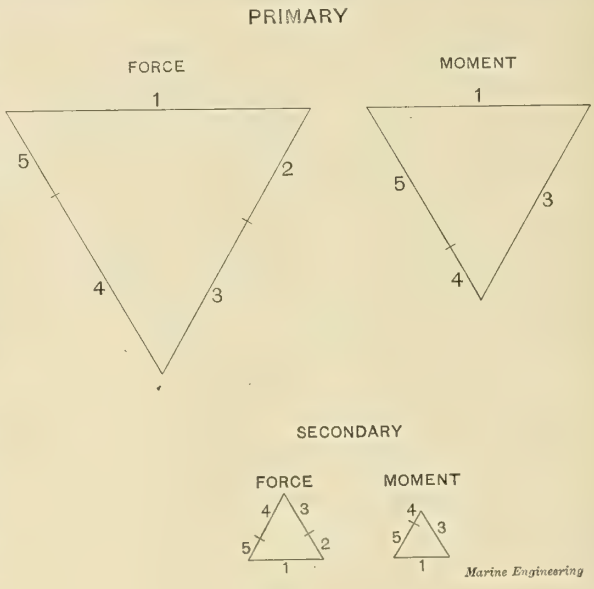


FIG. 13.

involving $\cos\theta$, $\cos 2\theta$, and $\cos 4\theta$, is zero, so that we may consider that primary, secondary, and tertiary forces all vanish.

Evidently, then, we should obtain almost an ideal balance with three-crank engines, as above, were it not for the fact that the cylinder axes, being not in the same line, moments are produced. Now, with a five-crank engine, we can make an arrangement virtually equivalent to a three-crank with cranks equally weighted and spaced, and the three cylinder axes coincident.

Two parallel cranks are equivalent to one crank with weight on it equal to the sum on the two, and located so that each of the two has the same moment about it.

To secure complete balance, then, with five cranks, it is necessary to arrange the heaviest weight in the middle, make the other cranks two and two parallel, one pair at 120 degrees with the middle crank, and the other pair at 240 degrees. Considering each pair, the moment of the weight on the forward crank about the middle one must be equal and opposite to the moment of the weight on the after parallel crank. Fig. 12 shows a diagrammatic arrangement with five cranks completely balanced, and Fig. 13 the corresponding primary and secondary force and moment polygons, which are seen to be equilateral triangles, one or more sides corresponding to two cylinders.

There has not been experience enough with the five-crank system to settle the best arrangements, but it is readily adapted to a quadruple engine with the first or second medium pressure divided into two. Fig. 12

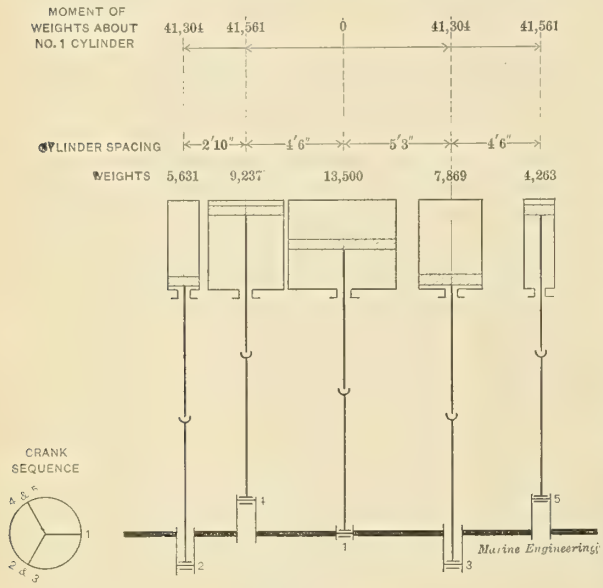


FIG. 12.

indicates the high pressure divided into two, but this appears undesirable for practical reasons. The two cranks corresponding to the divided cylinder should not be made parallel, but one should be parallel to the high pressure and one to the other medium pressure. This is for the purpose of gaining the most uniform turning moment possible. The five-crank completely balanced arrangement is practically as good as any arrangement as regards uniformity of turning moment.

REVOLVING BALANCE FOR FIVE CRANKS.

31. To secure complete revolving balance with the five-crank arrangement is not difficult. As a general thing the revolving weights would naturally be the same for each crank. If weight is added to the middle crank, and the revolving weights on each pair partially counter-balanced until for each pair the total virtual weight is equal to the virtual weight on the middle crank, and each one of the pair has the same moment about the middle crank, perfect revolving balance is secured. It is simpler and cheaper, however, to use two revolving balance weights, spaced as far apart as possible, as in the case of four-crank engines.

TABLE IV.

DATA GIVEN FOR ONE ENGINE IN EACH CASE.

	NAME OF VESSEL.														
	Charleston		Yorktown.			Vesuvius.				Cushing.					
No. of cylinders	2		3			4				5					
Length of stroke—feet	3.0		2.50			1.6667				1.25					
Length of crank arm—feet	1.5		1.25			0.8333				0.625					
Length of conn. rod—feet	6		5.333			3.75				3.125					
Value of N	4		4.267			4.5				5.0					
Max. I. H. P.	3333		1696			1897				860					
Max. revs. per minute	115		160			280				370					
Value of .000341 R^2	6.765		10.912			22.278				29.177					
Cylinder No.	1	2	1	2	3	1	2	3	4	1	2	3	4	5	
Aft or forward	Aft.	Ford.	Aft.		Ford.	Aft.			Ford.	Aft.				Ford.	
Leverage about aft crank—feet	0	6.75	0	5.65	925	0	3.5	7.5	11.0	0	3.50	9.00	132.5	17.25	
Crank ahead forward crank—degrees	270	0	120	240	0	90	270	180	0	216	72	288	144	0	
Actual recip. wt.—lbs	10000	6800	3000	2200	1800	1080	1080	1010	860	210	210	210	210	210	
Moment for primary polygon	0	45900	0	12430	16650	0	3780	7575	9460	0	735	1890	2782.5	3622.5	
Angle for secondary polygon	540	0	240	480	0	180	540	360	0	432	144	576	288	0	
Wt. for secondary polygon	2500	1700	703	516	422	240	240	224	191	42	42	42	42	42	
Moment for secondary polygon	0	11475	0	2913	3902	0	840	1683	2102	0	147	378	556.5	724.5	

BALANCE INCLUDING VALVE GEAR AND OTHER SECONDARY WEIGHTS.

32. An engine might be completely balanced as regards the main moving parts and yet develop very serious unbalanced forces due to its other moving weights, such as valve gears, air pumps, etc.

It is impossible to discuss in detail the possible cases which may arise in connection with these. In Appendix B I have shown how to determine the effects of any type of weight likely to be met with in practice. In balancing, skill and experience in applying the methods I have described are essential, but the modifications necessary to handle valve gears and other secondary weights are very simple in principle. Take an eccentric valve gear, for instance. The eccentrics driving it will be set at certain angles ahead or behind the crank of the cylinder; and the position of the crank once determined, the effect of the valve gear weights can be obtained. So when balancing a four-crank engine, for instance, first neglect the valve gears, and determine crank angles and main weights. This can be done at once from my diagrams A to F when the spacing of cylinders has been fixed. Then using these crank angles, determine the resultant unbalanced forces due to the valve gears. Next make a second approximation to the main gear weights and angles, so determining them that they are not in perfect balance with each other but balance the valve gears. In rare cases it may be necessary to repeat this process, but as a rule the second approximation to the main crank angles and weights is practically exact. The above is peculiarly applicable to the four-crank engine, where crank angles are varied in balancing. Engines with three or fewer cranks cannot be balanced anyhow. For five-crank engines with cranks 120 degrees apart, the valve gears must be balanced independently like the main gears. This is very simple, if the valves all supply steam on the outside or all on the inside. Then the eccentrics all have practically the same angular advance, and balancing is a question of weighting, which is easily arranged for.

Revolving secondary weights are easily combined with the main revolving weights, and if two revolving balance weights, spaced as far apart as possible, are used, they can readily be arranged to balance all revolving weights, main and secondary. One great advantage of this method of securing revolving balance is, that with provision made for the two balance weights, their exact amounts and angles need not be settled until the engine is practically completed and the exact revolving weights to be balanced known.

IMPORTANCE OF DRAWING FORCE AND MOMENT POLYGONS

33. In conclusion, I would recommend in the strongest manner that when designing an engine, whether for balance or not, complete force and moment polygons be always drawn, representing the effects of *every moving weight*, the weights being estimated. For completed engines, *actual weights* should be obtained and used for the polygons.

If complete or partial balance is aimed at, these polygons, correctly drawn, enable us to determine at a glance how closely the desired results have been obtained. As illustrating this, reference may be made to Fig. 6, showing the polygons for the five-crank engines of the *Cushing*. The force polygons are closed and the moment polygons have material resultants. It is evident that if the angles of the first and third cranks were interchanged the force polygons would still be closed, while the unbalanced moment resultants, both primary and secondary, would be but fractions of what they are in Fig. 6.

APPENDIX B.
Discussion of Various Appendages.

GENERAL PRINCIPLES.

1. In addition to the piston, piston rod, crosshead, connecting rod, crank pin, and crank arms, usually called the main gear, there are many moving parts, as a rule smaller and subsidiary, connected with every engine, such as valve gear, direct driven air pumps, etc.

The work of determining the effect of such weights as regards unbalanced forces and moments is, as a rule, more complicated than that of handling the main gear. The principles involved, however, are comparatively simple, and, with a systematic and orderly arrangement of the calculations, there is no difficulty in reaching correct results.

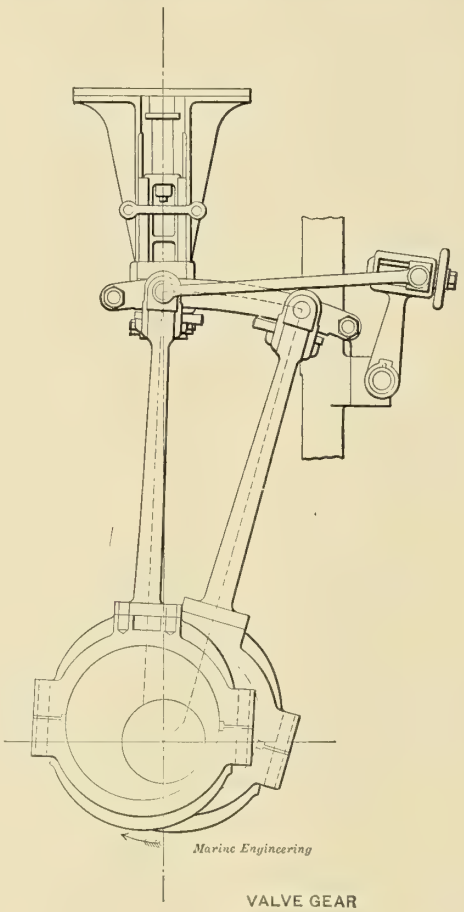
In handling such weights it is advisable always to reduce them as soon as possible to virtual weights, having the travel of the piston for reciprocating weights and revolving with the crank radius for revolving weights. The advantage of this is that one scale can be used for polygons of the secondary weights and main weights, and, in fact, one polygon can be drawn for both main and secondary weights.

In reducing the secondary weights to virtual weights having the same motion as the main weights, there is one point requiring especial care. As a rule, secondary reciprocating weights have not only a different stroke, but a different connecting-rod ratio from the main weights. For such a weight the virtual weight for primary diagrams is obtained very simply by multiplying it by the ratio (in all practical cases a fraction) between the travel of the secondary weight and the stroke of the engine. For the secondary diagrams, however, it is necessary to multiply this equivalent primary weight again, not by the connecting-rod ratio of the main weights, but by the connecting-rod ratio of the secondary weight.

The methods to be followed in dealing with the secondary weights can be best made clear from examples. I shall take three examples which will cover the ground as regards any case likely to occur in practice. They are:—

1. The ordinary double eccentric sliding link valve gear.

2. An air pump, lever driven from a crosshead.



VALVE GEAR

FIG. 14.

3. A bilge pump, eccentric driven from the main shaft.

VALVE GEAR.

2. The sketch, Fig. 14, which is not drawn to scale, shows an ordinary double eccentric valve gear in the go-ahead position, the data for it being as follows:—

DIMENSIONS.

Stroke of engine	42 inches.
Connecting-rod ratio for engine	4
Travel of valve	6 "
Eccentric rod length from center of sheave to center of top pin	84 "
Steam admitted on outside of valve	
Angular advance of eccentrics	135 degrees.

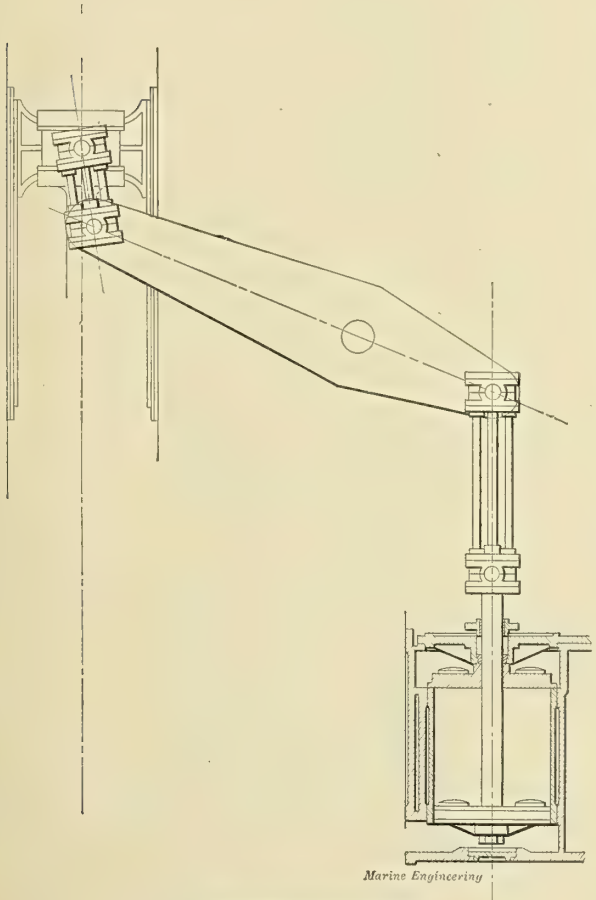
WEIGHTS.

Weight of valve, balance piston, valve stem and radius link block	1,446 lbs.
Weight of radius links	160 "
Weight of drag links or reversing links	92 "
Total weight of each eccentric rod and strap.	480 "
Weight of top half of eccentric rod	125 "
Weight of each eccentric sheave	275 "

It is necessary to separate the ahead gear from the astern gear and the revolving from the reciprocating weights.

The angular advance being 135 degrees, the ahead gear is driven by a crank 135 degrees ahead of the main crank of the cylinder to which the valve belongs, the astern gear by a crank 135 degrees behind, or preferably $360 - 135 = 225°$ ahead of the main crank.

	Ahead Gear.			Astern Gear.	
	Total. Weight.	Regarded as Reciprocating.	Regarded as Revolving.	Regarded as Reciprocating.	Regarded as Revolving.
Valve and rigid attachment	1446	1446	—	—	—
Radius links	160	80	—	80	—
Drag links	92	46	—	—	—
Eccentric rod and strap	480	125	355	125	355
Eccentric sheave	275	—	275	—	275
Totals		1698	630	205	630
Virtual primary weights—Factor $\frac{1}{7}$	—	243	90	29	90
Virtual secondary weights—Factor $\frac{1}{196}$	—	9	—	1	—
Crank ahead of cylinder crank		135°		225°	



LEVER DRIVEN AIR PUMP

FIG. 15.

The connecting-rod ratio for the valve gear is $\frac{3}{84} = \frac{1}{28}$.

The travel of the valve being six inches and the engine stroke forty-two inches, the primary reduction factor for the primary polygon is $\frac{6}{42} = \frac{1}{7}$. Since the connecting-rod ratio for the valve gear is $\frac{3}{84} = \frac{1}{28}$, for the secondary polygons the reduction factor becomes $\frac{6}{42} \times \frac{1}{28} = \frac{1}{196}$.

Taking up now the weights, first separate the actual weights into ahead and astern, reciprocating and revolving.

The first item—valve and rigid attachments—is all reciprocating and all belongs to the ahead gear.

The second item is 160 pounds for radius links. The radius links are driven by both the ahead and astern gear. They reciprocate with motion not absolutely harmonic, but it is an ample approximation if we divide the weight equally between the ahead and astern gear, giving 80 pounds to each.

The drag links, or reversing links, weigh 92 pounds. One end is at rest while the other reciprocates with the valve stem, since, as shown in the figure, these links take hold on the go-ahead end of the radius links. So we add 46 pounds to the go-ahead reciprocating weights.

Next we have the eccentric rod and strap. There is one for the ahead gear and one for the astern gear. This weight is like that of a connecting rod (which it is in essence) partly reciprocating and partly revolving, being concentrated at the two ends in the inverse ratio of the distances of its center of gravity

from the ends. In practice a very close approximation is obtained by regarding the weight of the top half of the rod as concentrated at the eccentric center and revolving. So for both ahead and astern gears we have, from the eccentric rods, 125 pounds reciprocating and 355 revolving.

The eccentric sheaves are, of course, all revolving, adding 275 pounds to both ahead and astern revolving weights.

LEVER DRIVEN AIR PUMPS.

3. Fig. 15 shows a very common type of appendage, namely, an air pump lever driven from the crosshead. Fig. 16 shows diagrammatically the dimensions and weights.

The simplest method of procedure is to determine the combined center of gravity of the whole gear, which, being driven off the crosshead, shares in its motion. This is done in the table below:—

Wt.	Amount Lbs.	Leverage about Lever axis.	Moment about Lever axis.
Crosshead links	120	— 40″	— 4800
Levers	570	— 7″	— 3990
Pump links	195	20″	3900
Reciprocating pump gear	1260	20″	25200
Sums	2145	9.47	20310

It is necessary now to collect the actual weights and apply the factors of reduction, by which we get the corresponding virtual weights reduced to engine strokes, etc.

The work is conveniently done in tabular form as indicated on page 113:—

The above gives us all the information to enable us to add to the main gear polygons lines covering the valve gear.

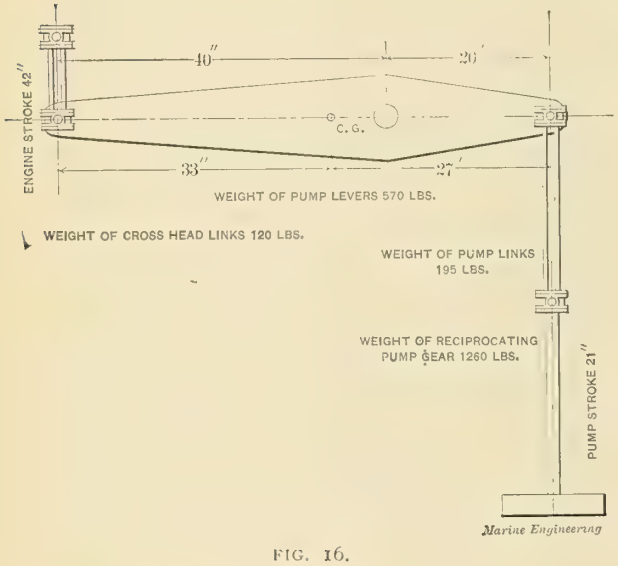


FIG. 16.

Now 2,145 pounds with a moment of 20,310 inch-pounds would be completely balanced by a weight at the crosshead end of the levers of 507.75 pounds. The effect of the air pumps as above, then, is to virtually reduce the reciprocating weight of the cylinder to which it is attached by 507.75 pounds. It will be

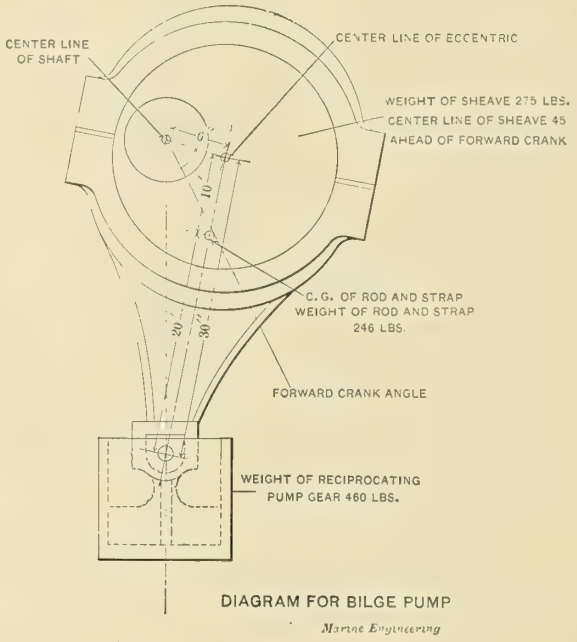

CENTER LINE OF SHAFT
CENTER LINE OF ECCENTRIC
WEIGHT OF SHEAVE 275 LBS.
CENTER LINE OF SHEAVE 45 AHEAD OF FORWARD CRANK
10
C. G. OF ROD AND STRAP
WEIGHT OF ROD AND STRAP 246 LBS.
20
30
FORWARD CRANK ANGLE
WEIGHT OF RECIPROCATING PUMP GEAR 460 LBS.
DIAGRAM FOR BILGE PUMP
Marine Engineering

FIG. 17.

If, as I consider desirable in practice, the secondary polygons are drawn with the same length of side as the primary, and the reduction factor or connecting rod ratio applied only to the resultants, the virtual secondary weights to be used in such case would be, for the engine in question (connecting-rod ratio = 4), four times as great as given above, the factor used being $1/196 \times 4 = 1/49$.

The moments follow directly from the weights, given the leverage of the valve center about the after crank.

observed that I neglected the obliquity of the links at the lever ends. This is because the effect of this obliquity upon the motion is infinitesimal.

BILGE PUMP ECCENTRIC DRIVEN.

4. The third and last type of auxiliary which I shall consider is that of a bilge pump eccentric driven.

Fig. 17 shows diagrammatically such an appendage.

Stroke of engine is taken as 84 inches, which is seven times the pump stroke. Connecting-rod ratio for engine is 4 and for the pump is 30/6=5. Center of

pump is 10 feet forward of after crank center. In the case of this appendage we have a slight complication, owing to the fact that the bilge pump is below the shaft instead of above, as the cylinders are. A little consideration will make it obvious that primary polygons are not affected, but for secondary polygons the sides must be measured in the opposite direction to the crank direction obtained by doubling the actual angle, a result which is most conveniently reached by regarding the sides of the secondary polygons representing this appendage as negative. The methods applicable to this case are obvious, and the table below shows their application.

Items.	Actual Weight.	Regarded as Reciprocating.	Regarded as Revolving.
Eccentric sheave	275	....	275
Eccentric rod and strap	246	82	164
Reciprocating pump gear	460	460	....
Totals	...	542	439
Virtual primary weights—factor $\frac{1}{7}$	....	77	63
Virtual secondary weights—factor $\frac{1}{7} \times \frac{6}{30}$	....	—15.5	....
Virtual primary moments—factor $\frac{10}{7}$	....	774	627
Virtual secondary moments—factor $\frac{10}{35}$	....	—155	....

If, as I recommend, it is intended to draw secondary polygons with sides the same length as primary polygons, applying the connecting-rod ratio of the main gear, afterwards the factor for virtual secondary weights becomes 4/35, and for virtual secondary moments 40/35.

These make the virtual secondary weight for the reciprocating secondary force polygon 61.9, and the virtual secondary moment 619.

APPENDIX C.

Analysis and Discussion of Four-Crank Balance.

PRELIMINARY DEFINITIONS AND CONSIDERATIONS.

1. In taking up the question of the balancing possibilities, so to speak, of the four-crank engine, it seems desirable at first to cover the whole practicable field by determining crank angles and weights for primary balance throughout the range of possible cylinder spacings liable to occur in practice. In doing this I designate the cylinders by the numbers 1, 2, 3, and 4; No. 1 being aft, and No. 4 forward; then the reciprocating weights for the respective cylinders are denoted by w_1, w_2, w_3, w_4. The crank angles are measured in the direction of rotation from the direction of the forward crank. This is simply a matter of convenience. Any direction fixed with relation to the crank shaft could be used, but just as it is convenient to take moments about the after center, so it is convenient to measure angles from the forward crank. Another point to be noted in this connection is, that as long as the angles are measured in the same direction, they may be laid off either forward or backward; that is to say, all in the direction of rotation, or all opposite to the direction of rotation. This is a matter which may be of some importance when considering turning moments. The crank angles, then, referred to the direction of the forward or No. 4 crank, are denoted by a_1, a_2, a_3, and a_4, the latter being always =0. As moments are taken about the after center, the distances or levers are measured from the after center. The distances, then, from the after center to the centers of the second, third, and fourth cylinder are denoted by l_2, l_3, and l_4. Since what we have to consider are ratios rather than absolute values, we may take any one reciprocating weight as always equal to unity and determine the ratios of the rest to it, and any one length as equal to unity and determine the ratios of the other lengths to it. It is evidently convenient to take the length of the engine from the after to the forward cylinder as unity—or l_4—equal to unity. It naturally follows, then, that we assume the forward reciprocating weight, or w_4, also equal to unity.

I invite attention now to Fig. 18, which shows the force and moment polygons both primary and secondary for a four-cylinder engine, as described above. It is seen that the primary moment and primary force polygons are both closed—that is to say, return to the origin, 0. The secondary force and moment polygons are open—that is, there is a resultant. For convenience, the sides of the secondary polygons are the same length as the corresponding sides of the primary polygons, but it should be understood that the actual corresponding forces are, for the secondary, only $\frac{1}{n}$ those of the primary polygons where n is the connecting-rod ratio. The angles in every case are measured counter-clockwise from the direction OA. In the secondary polygons this may, and usually does, result in some angles being greater than 360 degrees. Thus, in the primary polygons, a_2 is about 255 degrees, so that $2a_2$ is about 510 degrees, or 360 plus 150.

DEDUCTION OF FORMULÆ FOR ANGLES AND WEIGHTS NOT ASSUMED AS KNOWN AND FOR RESULTANTS.

2. It is necessary next to deduce expressions or formulæ connecting the lengths of the sides and angles of the primary polygons, which are closed, and then to determine the resultants in the case of the open secondary polygons.

Consider, first, the primary moment polygon: This involves only the second, third, and fourth cylinders, since moments are taken about the first cylinder, and hence its moment is always zero. We assume that we know w_2, w_3, w_4, l_2, l_3, and l_4, and hence w_2l_2, w_3l_3, and w_4l_4.

From well-known trigonometric formulæ, we have from the primary moment polygon.

$$\cos OAB = \frac{\overline{OA}^2 + \overline{AB}^2 - \overline{BO}^2}{2\,OA \times AB} = \frac{w_4 l_4 + w_3 l_3 - w_2 l_2}{2\,w_4 l_4 w_3 l_3}.$$

Whence, as w_4 and l_4 are each taken equal to unity,

$$\cos (180° - a_3) = \frac{1 + \overline{w_3 l_3}^2 - \overline{w_2 l_2}^2}{2\,w_3 l_3}.$$

Similarly

$$BOA = a_2 - 180°.$$

$$\cos BOA = \cos (a_2 - 180°) = \frac{1 - \overline{w_3 l_3}^2 + \overline{w_2 l_2}^2}{2\,w_2 l_2}.$$

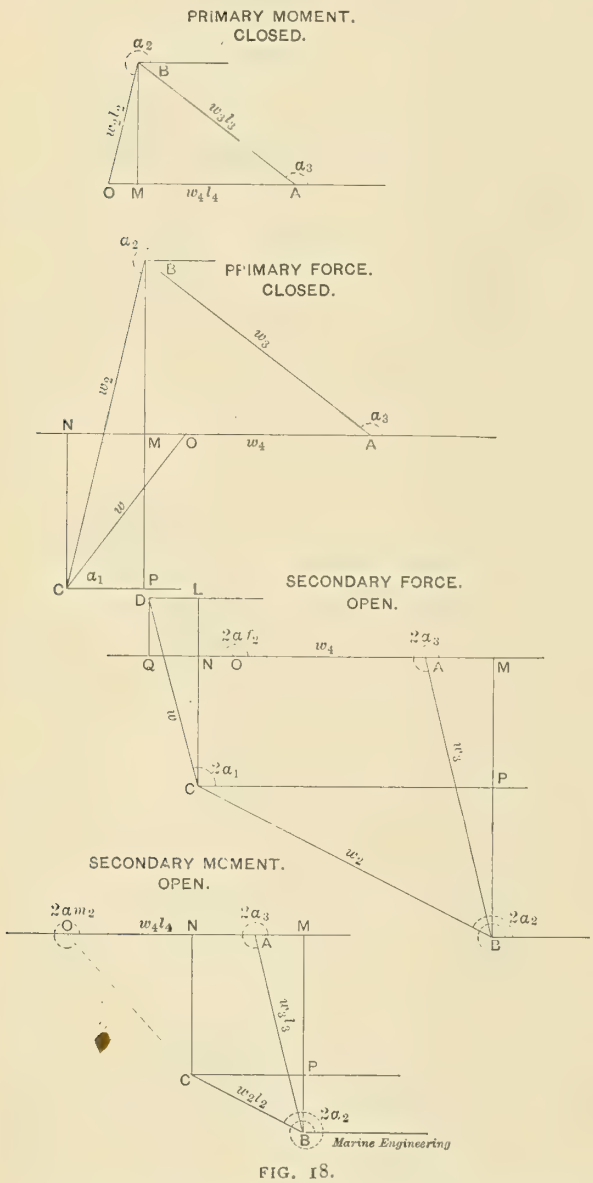


FIG. 18.

The above determine a_2 and a_3 the only unknown quantities in connection with the second and third cylinders.

It is next necessary to determine the weight and crank angle for the first cylinder. For this we use the primary force polygon. The formulæ are as follows:—

The polygon being closed, and each line being measured from the first extremity indicated to the second (*i. e.*, OA is a distance from O to A and AO is a distance from A to O), we have in the primary force polygon of Fig. 18.

$$OA + AM + MN + NO = 0,$$

or

$$1 + w_3 \cos a_3 + w_2 \cos a_2 + w_1 \cos a_1 = 0.$$

Also,

$MB + BP + CN = 0$, or $w_3 \sin a_3 + w_2 \sin a_2 + w_1 \sin a_1 = 0$.

Whence

$$\tan a_1 = \frac{w_3 \sin a_3 + w_2 \sin a_2}{1 + w_3 \cos a_3 + w_2 \cos a_2}$$

$$w_1 = \{(1 + w_3 \cos a_3 + w_2 \cos a_2)^2 + (w_3 \sin a_3 + w_2 \sin a_2)^2\}^{1/2}.$$

It is next necessary to determine the resultants in

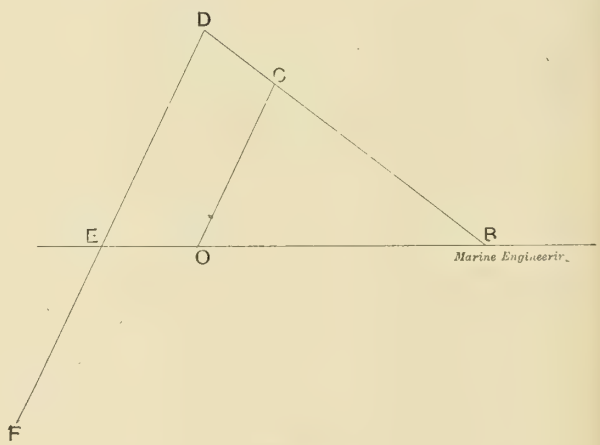


FIG. 19.

the secondary force and moment polygons. Referring to the open secondary force polygon, we have

$$OQ = OA + AM + PC + LD,$$
$$QD = MB + BP + CL.$$

The resultant OD is n times the unbalanced secondary force $= nf_2$ say. Denote the angle DOM by $2af_2$. Then

$$OQ = nf_2 \cos 2a_{f_2} = 1 + w_3 \cos 2a_3 + w_2 \cos 2a_2 + w_1 \cos 2a_1,$$
$$QD = nf_2 \sin 2a_{f_2} = w_3 \sin 2a_3 + w_2 \sin 2a_2 + w_1 \sin 2a_1.$$

Whence

$$\tan 2a_{f_2} = \frac{w_3 \sin 2a_3 + w_2 \sin 2a_2 + w_1 \sin 2a_1}{1 + w_3 \cos 2a_3 + w_2 \cos 2a_2 + w_1 \cos 2a_1},$$

$$nf_2 = \{(1 + w_3 \cos 2a_3 + w_2 \cos 2a_2 + w_1 \cos 2a_1)^2 + (w_3 \sin 2a_3 + w_2 \sin 2a_2 + w_1 \sin 2a_1)^2\}^{1/2}.$$

Finally, for the determination of the resultant secondary moment, referring to the open secondary moment polygon, we have, if nm_2 denote the secondary moment and $2am_2$ its angle

$$ON = OC \cos NOC = nm_2 \cos 2\,am_2$$
$$= OA + AM + PC = 1 + w_3 l_3 \cos 2a_3 + w_2 l_2 \cos 2a_2,$$
$$NC = OC \sin NOC = nm_2 \sin 2am_2$$
$$= MB + BP = w_3 l_3 \sin 2a_3 + w_2 l_2 \sin 2a_2.$$

Whence

$$\tan 2am_2 = \frac{w_3 l_3 \sin 2a_3 + w_2 l_2 \sin 2a_2}{1 + w_3 l_3 \cos 2a_3 + w_2 l_2 \cos 2a_2},$$

$$nm_2 = \{(1 + w_3 l_3 \cos 2a_3 + w_2 l_2 \cos 2a_2)^2 + (w_3 l_3 \sin 2a_3 + w_2 l_2 \sin 2a_2)^2\}^{\frac{1}{2}}.$$

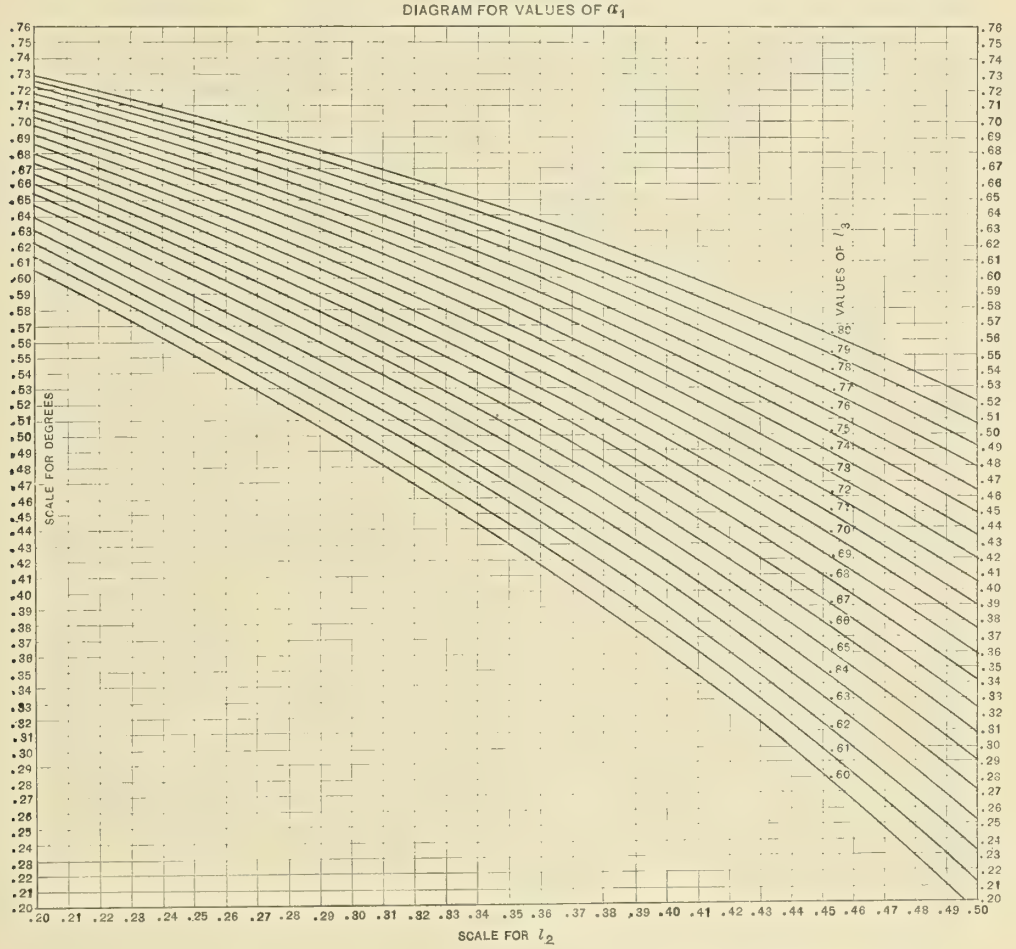
GRAPHIC REPRESENTATION OF RESULTS OF FORMULÆ AND CONCLUSIONS.

The author herein further discusses the diagram, reference to which has been made in section 27, closing with the following summary:—

A final fact, which is evident from the diagram, is that the best results as regards turning moment and residuary secondary force and moment appear to be developed when the second and third weights are both somewhere near 1.5. When this is the case, the first weight is generally not far from unity, or the value of the fourth weight, and in general the distribution of crank angles and weights is good. It is evident from this diagram that detailed investigation then may be restricted to combinations in which the angle of the first crank is from about 40 degrees to about 60 degrees; the angle of the second is something less than 270 degrees, and the angle of the third some 20 to 40 degrees less than 180 degrees. It is evident, moreover, from the diagram, that it will be practically impossible to eliminate altogether resultant secondary moments, while it appears probable that resultant secondary forces can be eliminated. The problem is then to determine the combinations where primary forces and moments are all eliminated, and then determine the corresponding resultant secondary moments. I have found that this can be done without a prohibitive amount of labor by a new graphic process.

DIAGRAM A.

DIAGRAM FOR VALUES OF a_1



DETERMINATION OF DIAGRAMS FOR FOUR-CRANK BALANCE, WHICH IS COMPLETE EXCEPT AS TO SECONDARY MOMENTS.

4. Referring to Fig. 19, suppose that *OBC* is a closed moment polygon, and *OBDF* the three corresponding sides of a primary force polygon, then we have

From the moment polygon:—	From the force polygon:—
$OB = w_4 l_4$	$OB = w_4$
$BC = w_3 l_3$	$BD = w_3$
$CO = w_2 l_2$	$DF = w_2$
$OB = BC \frac{w_4 l_4}{w_3 l_3}$.	$OB = BD \frac{w_4}{w_3}$

Whence

$$BD \frac{w_4}{w_3} = BC \frac{w_4 l_4}{w_3 l_3}$$

$$BD = BC \frac{l_4}{l_3}$$

DIAGRAM B.

DIAGRAM FOR RATIOS $W_1 \div W_4$

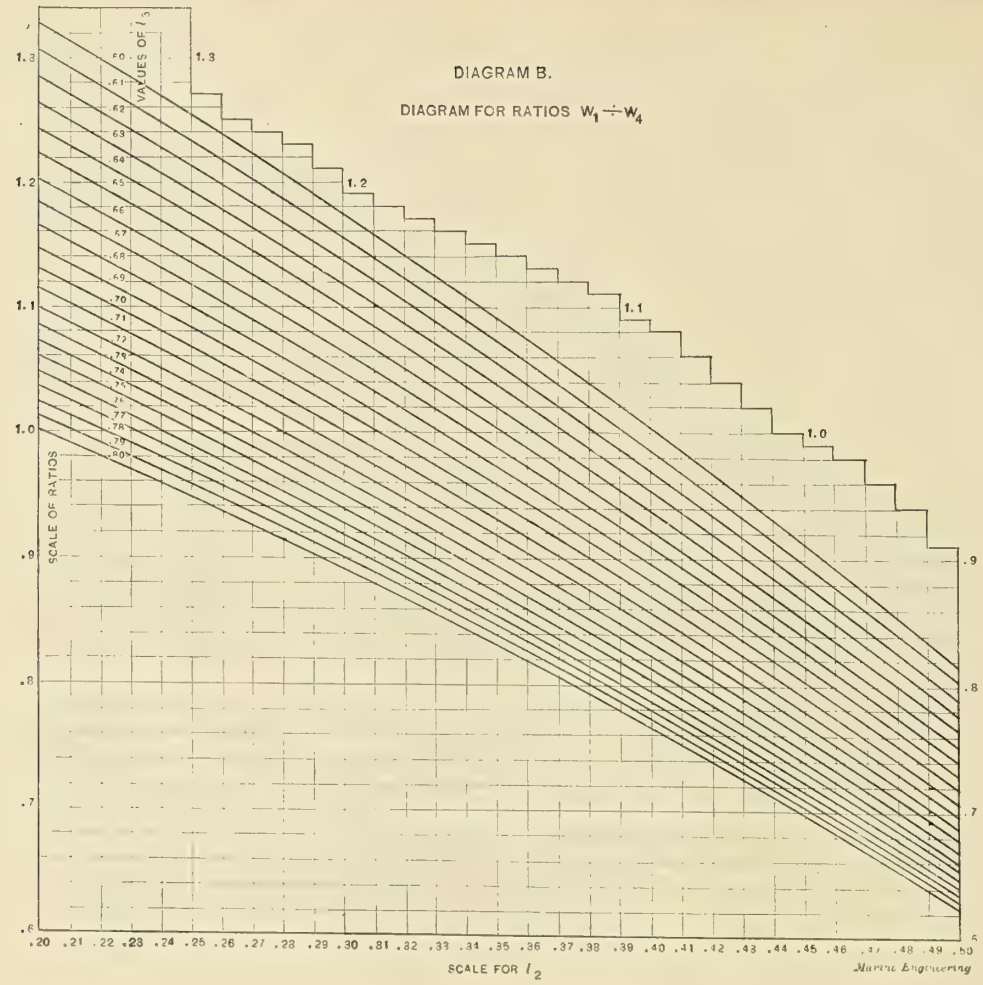


DIAGRAM C.

DIAGRAM FOR VALUES OF a_2

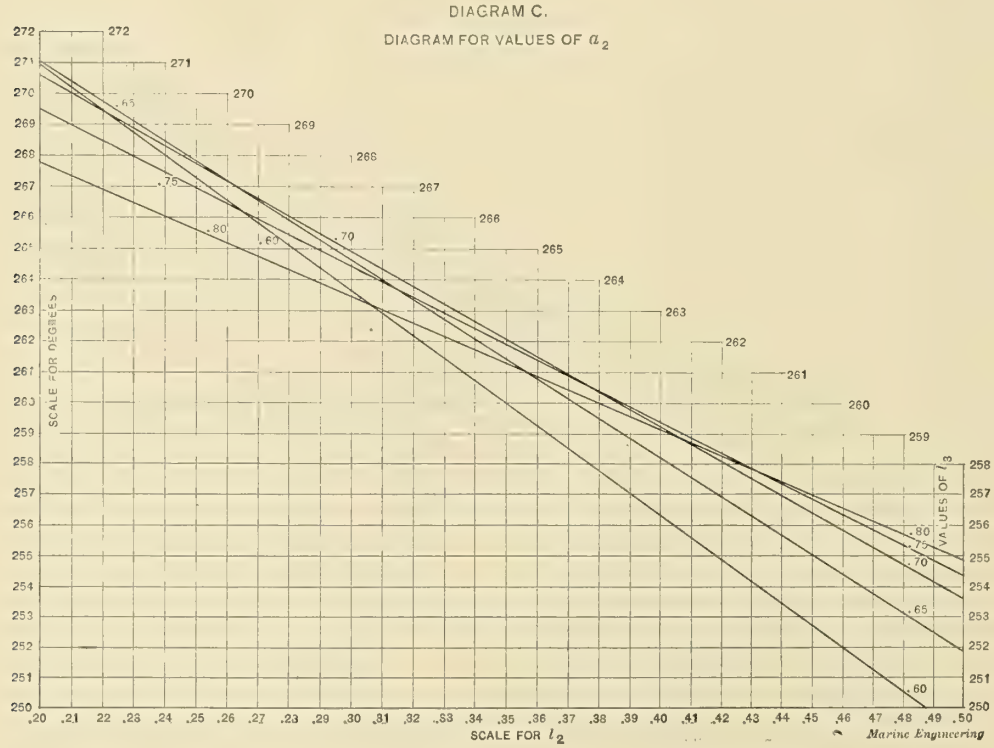


DIAGRAM D.

DIAGRAM FOR RATIOS $W_2 \div W_4$

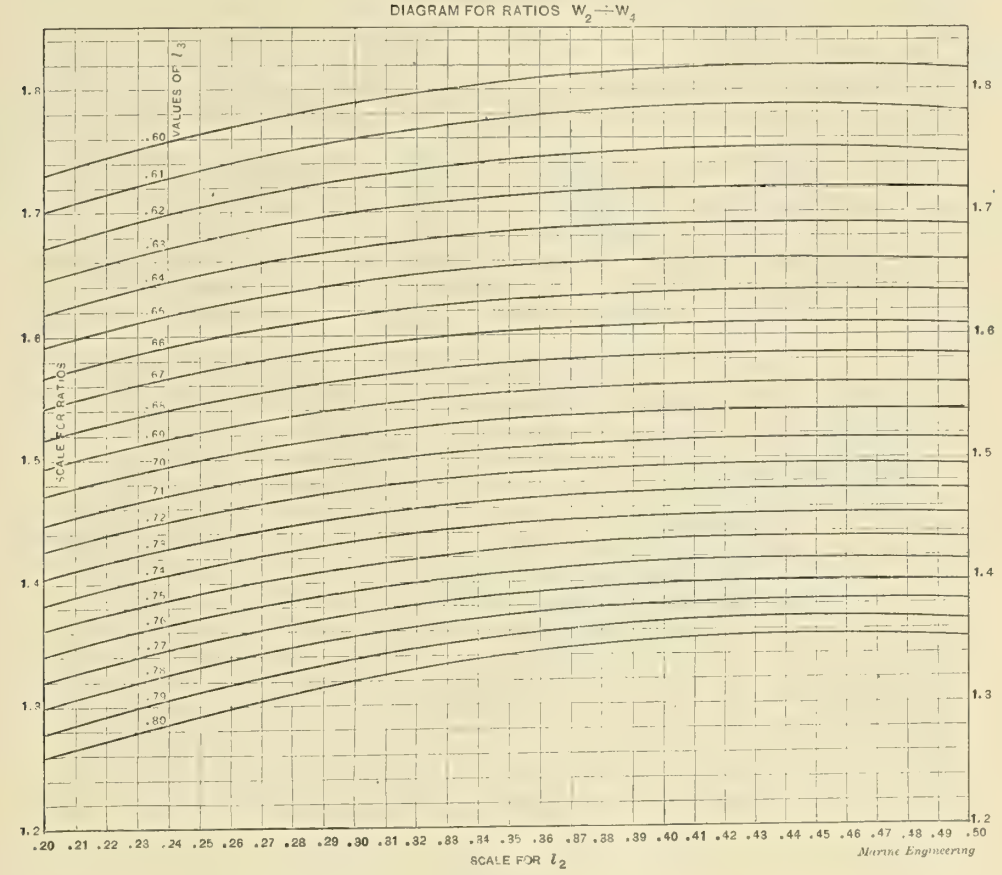
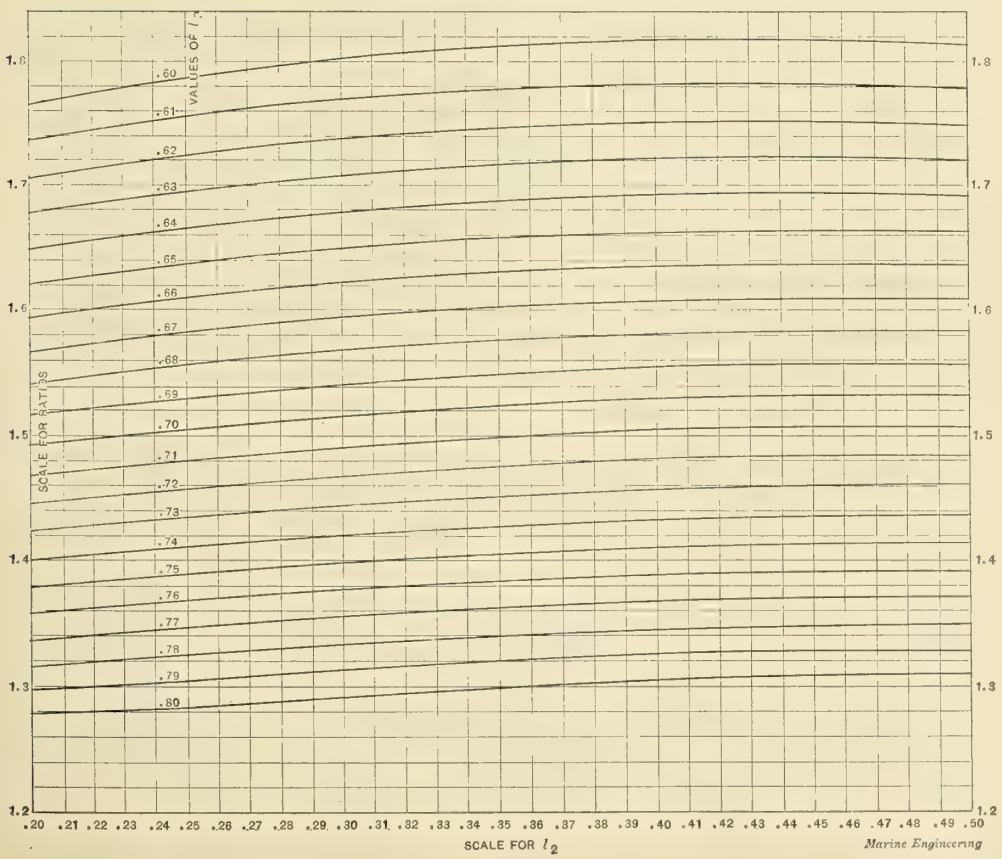


DIAGRAM F.

DIAGRAM FOR RATIOS $W_3 \div W_4$



$$CD = BD - BC = BC\frac{l_4 - l_3}{l_3}$$

Now by similar triangles

$$\frac{OE}{OB} = \frac{CD}{CB} = \frac{l_4 - l_3}{l_3}$$

Whence for given relative values of l_4 and l_3 and a constant value of BO or w_4, the line DF of the force polygon representing w_2 passes always through a fixed point E on BO extended. Furthermore, DF is divided at the point E in a ratio depending on l_2 and l_3.

For

$$DF = OC\frac{l_4}{l_2} \cdot DE = OC\frac{l_4}{l_3}.$$

Whence, finally,

$$\frac{DE}{EF} = \frac{l_2}{l_3 - l_2}.$$

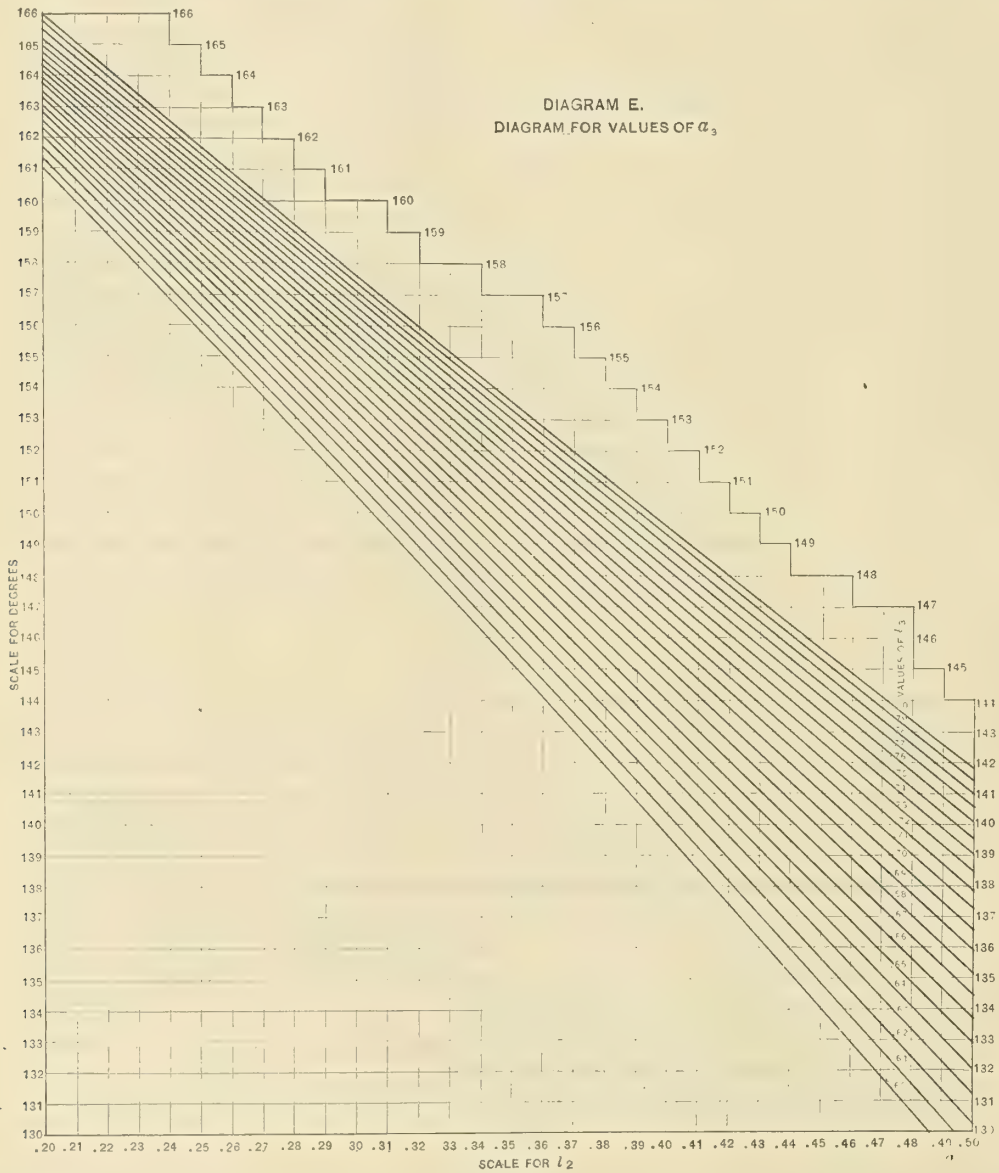
Evidently, then, if in drawing a primary force polygon, given w_4, l_4, l_3 and l_2, we determine the point E from the formula

$$\frac{OE}{OB} = \frac{l_4 - l_3}{l_3},$$

and then draw a line DF at any inclination through E, determine D and F from the formula $\frac{DE}{EF} = \frac{l_2}{l_3 - l_2}$, then join FO, DB, we have a closed primary force polygon for which the primary moment polygon is also closed. The primary moment polgon is given at once by drawing OC through O parallel to DF.

Since we can draw any number of lines, such as DF, we can determine any number of weights and angles giving primary balance for given lengths of engine, given forward reciprocating weight, and given position of the second and third cylinders. This being the case, we can impose another condition. For instance, we can so determine the angles and corresponding

DIAGRAM E.
DIAGRAM FOR VALUES OF α_3



weights as to get a desirable turning force, *i. e.*, the torque as uniform as possible during a revolution. Or we can determine weights and angles which reduce the secondary force to zero or *close* the secondary force polygon. This is readily done by trial and error. Assume a value and position of *DF* and draw the corresponding secondary force polygon. Guided by this, assume a second value and position of *DF*, for which the secondary force polygon is more nearly closed, and so on. I found in practice that after about three successive values of *DF* I could determine the value giving a closed secondary force polygon. It was in this way that I obtained data from which to plot the diagrams A to F, giving values of a_1, a_2, a_3, w_1, w_2 and w_3. These diagrams are practically correct. After they

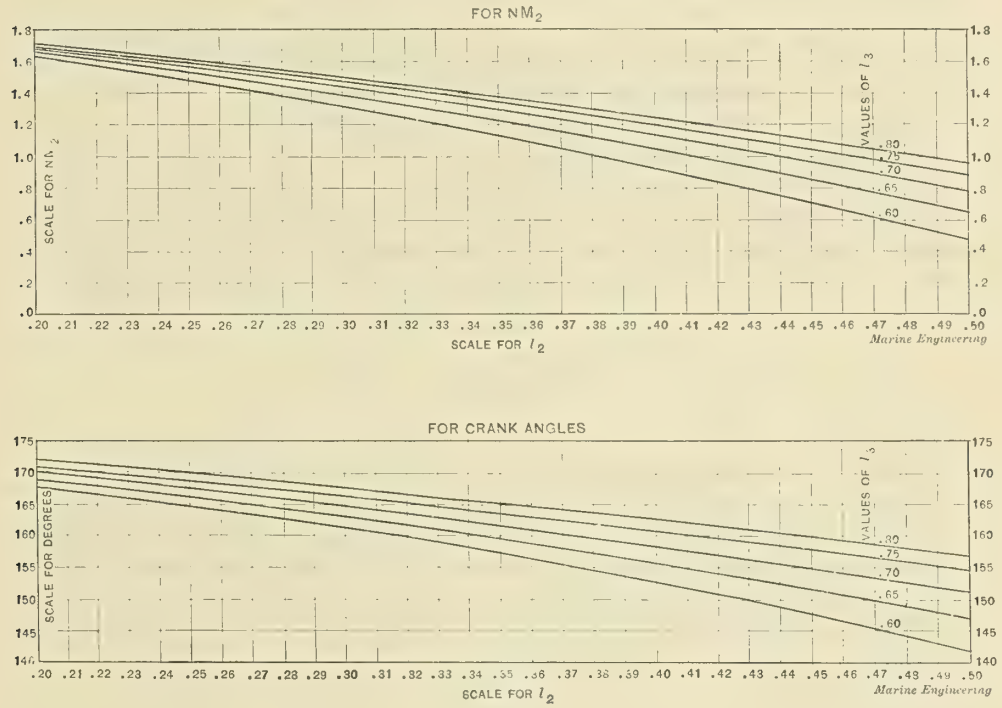
grams A, C and E give the first approximation to each crank angle, and hence to each eccentric angle since the angle of advance is known for each eccentric. From these draw the primary and secondary force and moment polygons of the valve gear. These will, in general, have resultants. Now determine new weights and angles for the main gears, such that they are not in balance but *balance* the valve gears. This is a second approximation. Continue the process until the results are practically exact. The process is comparatively short and simple, and gives substantially exact results.

SOME GENERAL CONCLUSIONS.

6. An inspection of the weight and angle diagrams shows that the weights for the middle or heavy cranks

DIAGRAM G.

DIAGRAM FOR RESIDUAL SECONDARY MOMENTS



were plotted and traced, I took off values of a_1, a_2, etc., for 35 values of l_2 and l_3 and *calculated* the resultants of primary and secondary force and moment polygons. The primary and secondary force and primary moment polygons were practically closed in every case. The results as regards the secondary moments are given in diagram G.

MODIFICATIONS NECESSARY BECAUSE OF VALVE GEARS, ETC.

5. The six weight and angle diagrams for the determination of a_1, a_2, a_3, w_1, w_2 and w_3, can, of course, be used for the main reciprocating weights only. When considering the valve gears and other secondary weights, additional work is necessary, which may be briefly outlined as follows:—

From the given cylinder locations determine the weight ratios. From the weight ratios determine the actual weights neglecting valve gears. The angle diagrams are apt to be nearly the same, while those for the end cranks differ materially and are lighter than either of the others. That is, if applied to quadruple engines, the high pressure and first medium pressure should be at the ends of the engine. The diagrams are drawn primarily for No. 1 cylinder aft, No. 4 forward, and the crank angles measured in the direction of rotation of the engine. It is quite permissible, however,

1. To lay off all crank angles opposite to the direction of rotation. This follows from the fact that a balanced engine is balanced for rotation either ahead or astern. To gain a better curve of torque it may be desirable to set off crank angles in one direction rather than the other.

2. To turn the engine bodily end for end. This will often be desirable in order to bring the lightest cylinder—the high pressure—at the forward end of the engine.

CHANGES AND AMENDMENTS IN THE RULES OF THE UNITED STATES BOARD OF SUPERVISING INSPECTORS OF STEAM VESSELS.

Approved by the Secretary of the Treasury and Published under date of February 7, 1902.

Note. The changed or new matter is designated by italics.

RULE II.

Section 6. (Last paragraph.)

But no flat surface shall be unsupported at a greater distance in any case than [16] *18* inches, * * *

Section 9. (New, at end of second paragraph, page 31, Rules).

Wrought iron tubes, however, may be used without being subjected to the tests required from tubes made of Bessemer, acid or basic open-hearth steel.

Section 26.

* * * *The bronze casing* of all fusible plugs, unless otherwise provided, shall have an external diameter *of* not less than that of a [1—] *three-quarters of an* inch gas or steam pipe screw tap, except when such plugs shall be used in the tubes of upright boilers, plugs may be used with an external diameter of not less than that of a three-eighths of an inch gas or steam pipe screw tap [said plugs to conform in construction with plugs now authorized to be used by this board]; and no such plugs shall be used unless the core of the plug is filled with good Banca tin from end to end of the bronze casing; and it shall be the duty of the inspectors to see that these plugs are *so* filled [with Banca tin] at each annual inspection.

The manufacturers of fusible plugs, whether boiler makers or others, shall stamp their name thereon for identification, and file with the local inspectors in the districts where their plugs are in most general use a certification stating that the fusible plugs manufactured by them are filled with good Banca tin, in the manner described in this section.

Section 38.

* * * All copper steam pipes shall be flanged *over or outward* to a depth of not less than [four times] *twice* the thickness of the material in the pipes, * * *

The flanges of all copper steam pipes over 3 inches in diameter shall be made of bronze or brass composition, shall be securely brazed *or riveted* to pipe, * * *

The terminal and intermediate joints of all wrought iron and homogeneous steel feed and steam pipes over 3 inches in diameter, other than on pipe or coil boilers or steam generators, shall be made of wrought iron, homogeneous steel, or flanges of equivalent material; and all such flanges shall have a depth through the bore of not less than that equal to one-half of the diameter of the pipe to which any such flange may be attached; and such bores shall taper slightly outwardly toward the face of the flanges; and the ends of such pipes shall be enlarged to fit the bore of the flanges, and they shall be substantially beaded *over or outward* into a recess in the face of each flange. * * *

All lap-welded iron or steel steam pipes over [5] *5½* inches in diameter or riveted wrought iron or steel *or seamless drawn steel* steam pipes over [5] *5½* inches in diameter, in addition to being expanded into tapered holes and substantially beaded into recess in face of flanges, shall be substantially and firmly riveted with good and substantial rivets through the hubs of such flanges; and no such hubs shall project from such flanges less than 2 inches in any case. *Provided, however, that when such pipes are double riveted into cast steel, wrought iron or homogeneous steel flanges, said flanges to be equal in strength to the strength of the pipe, the process of expanding and beading may be dispensed with. It is further provided that for pressures of 100 pounds and under said pipes may be single riveted to the flanges in lieu of double riveting. The joints of all flanges shall be made with a sufficient number of good and substantial bolts or rivets, to make such joints at least equal in strength to all other parts of the pipe.*

Section 39. (First and second paragraphs.)

39. All coil and pipe boilers hereafter made, when such boiler is completed and ready for inspection, must be subjected at *the first* inspection to a hydrostatic pressure double that of the steam pressure allowed in the certificate of inspection—to take effect on and after July 1, 1897.

The use of *malleable iron or* cast steel manifolds, tees, return bends or elbows in the construction of pipe generators shall be allowed, * * *

RULE V.

Section 2. (Fourteenth paragraph.)

Engineers of lake, bay and sound steamers who have actually performed the duties of engineers for a period of three years shall be entitled to examination for engineer of ocean steamers, applicant to be examined in the use of salt water, method employed in regulating the density of the water in boilers, the application of the hydrometer in determining the density of sea water, and the principle of constructing the instrument, and shall be granted such grade as the inspectors *having jurisdiction on the great lakes* may find him competent to fill.

RULE IX.

Section 1. (New, added to section.)

Local inspectors, in determining the distance between the flues and the shells of externally fired boilers, under provisions of section 4,434, Revised Statutes of the United States, shall take the measurements from the plate in the flue to the plate in the shell.

APPENDIX TO THE RULES.

(New. Added after last paragraph, page 83, Rules and Regulations of 1901.)

To determine the pitch of rivets from the above formulas use the diameter and area of the rivet holes. The diameter of the rivets as given in the following tables is the diameter of the driven rivet.

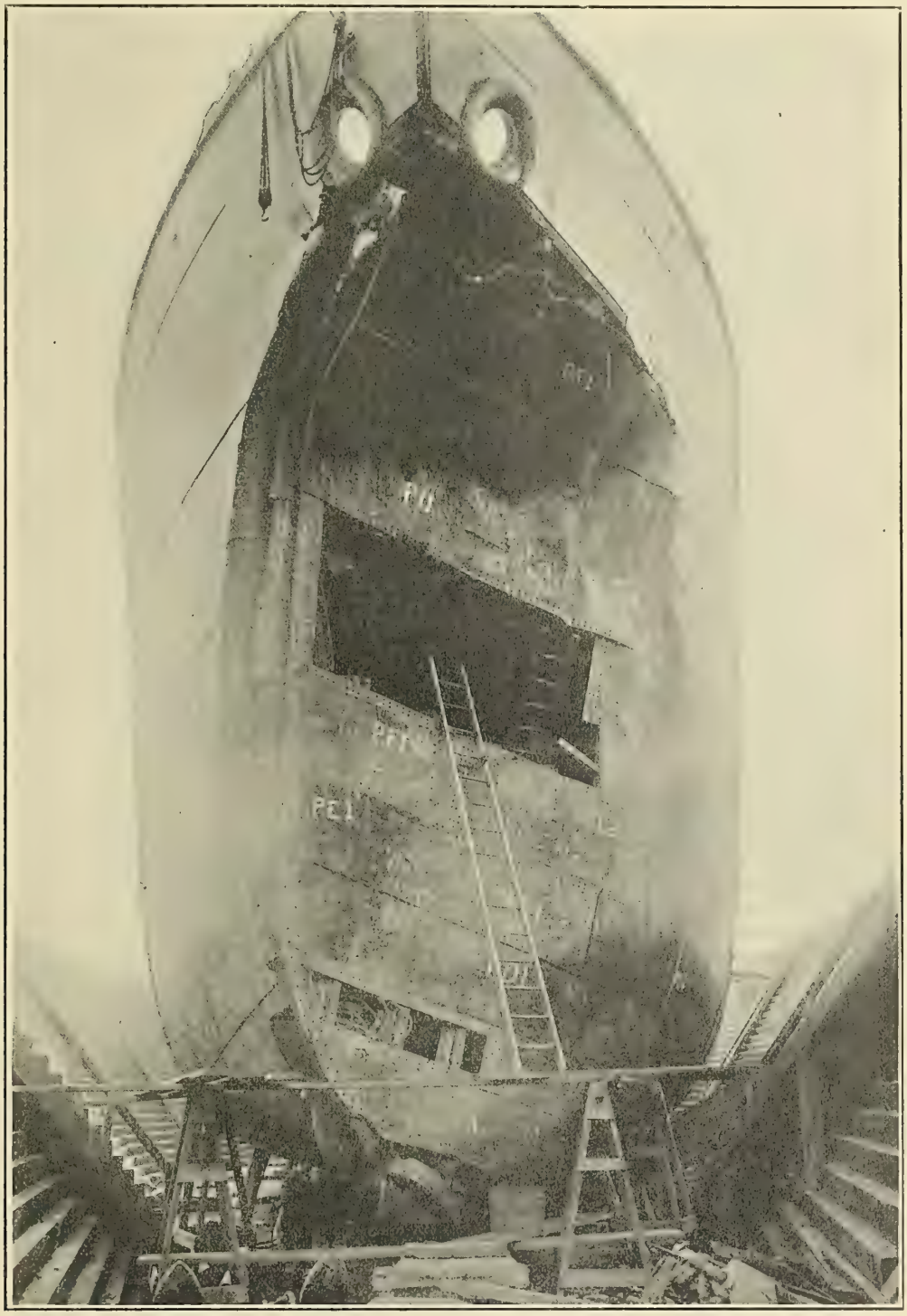
Any riveted joint will be allowed, when it is constructed so as to give an equal percentage of strength to that obtained by the use of the formula given.

Chicago Shipbuilding. — During the year 1901 there were built at Chicago, eight steel freight steamships of an aggregate tonnage of 21,178 tons and costing $1,895,000.

New Havana Drydock.—The Havana Drydock Company, of Havana, Cuba, has opened its new steel floating drydock. The length of the main box is 280 feet; width, 88 feet 2 inches; the additional riggers on each end are 40 feet in length, bringing the total length of the dock to 360 feet.

Replacing a Damaged Bow.

The accompanying illustrations show the bow of the steamer *Isle of Kent*, which, on the 14th of December, was in collision with the Spanish ship *Amesti* while



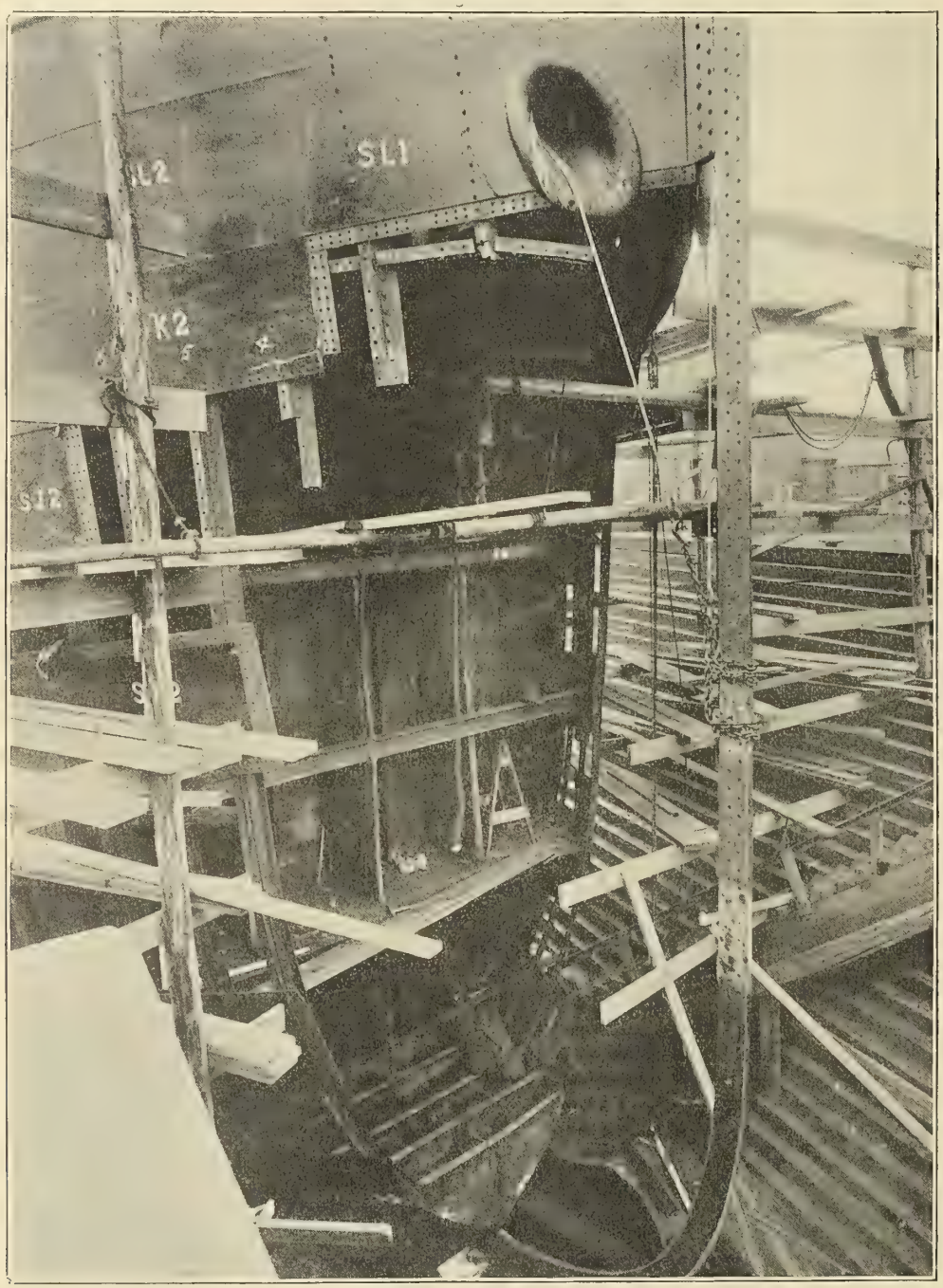
DAMAGE TO THE BOW OF A STEAMER AFTER COLLISION AT SEA.

350 miles east of Boston Light. The *Isle of Kent* struck the other ship bows-on on the starboard side and her stem was folded up in the manner shown in the first engraving. The *Amesti* sunk within 15 minutes, but her crew was saved. The collision bulkhead of the *Isle of Kent* saved this ship from going to the bottom. She proceeded to Boston and was docked and surveyed.

The contract was awarded the Fore River Ship and Engine Company, who agreed to complete the work within 25 days. Within three days from the signing of the contract the steel forging for the stem was

completed at the forge works of this company. This forging was in one piece 62 feet by 10 by 2 3-4 inches. The company's floating machine shop was towed from the plant at Quincy to the dry dock and their steam lighter was kept in service between these two points.

New Organization. — The American Shipmaster's Protective Association of sail vessels completed its organization in Newport News on January 30th, with Capt. H. H. Haines, of Taunton, Mass., president, and A. L. Crowley, of Boston, Mass., secretary. The



DAMAGED PLATES REMOVED AND NEW STEM FITTED.

The damaged bow plates and frames were first cut out by pneumatic tools and a new bow built on. The second illustration represents the hull made ready to receive the new material with the new stem in place. The work was completed within contract time, making a record job for quick repair.

headquarters of the organization will be in Boston, but branches will be established in every port on the Atlantic coast, with a legal representative in each. The object is to secure the repeal of laws adverse to the interests of masters and owners of sailing vessels, and obtain the enactment of other laws to their interests.

LAKE BUILT OCEAN TRAMP STEAMERS.

BY CHARLES C. WEST.

The advent of the American Ship Building Company into the field of the construction of ocean boats has been signalized by the fulfilment of orders for two steamers placed with them by the American Navigation Company, of New York. In the past quite a number of canal size ocean boats have been built on the Great Lakes, but in the *Minnetonka* and *Minnewaska* come the first real encroachment of the American Ship Building Company upon what has always been considered the rightful province of the coast shipbuilders.

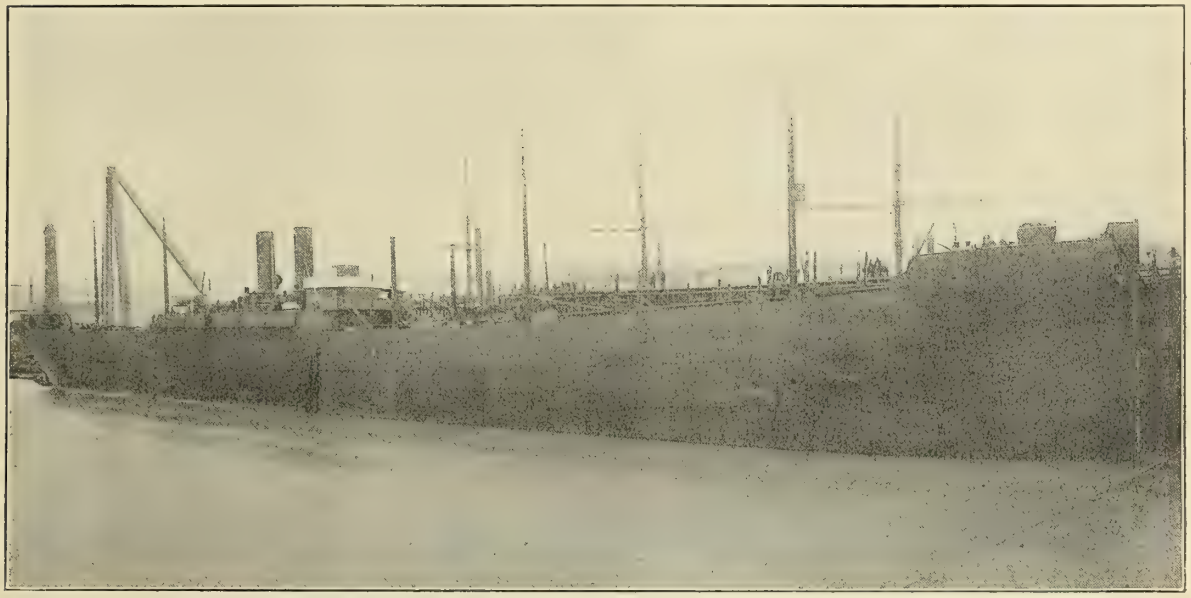
The capability of the fresh water builder has never been doubted, but natural disadvantages that restricted the size which could be taken to the salt water seemed to fully define his field. Therefore, the middle continent shipyards have gone on for years simply supplying the local demand for ships, but in the performance of this, as is well known, have developed original, effective and economical methods of construction. It is, therefore, with a confidence born of long experience that the American Ship Building Company enters upon this new field of operations.

The canals, which represent the only feasible waterway between the Great Lakes and the ocean, restrict the size of the boat bound for salt water to about 250 feet, and the demand for craft of this size being small, compelled the American Ship Building Company to adopt the plan of building ocean boats of large size, cutting them in two parts, taking them to the coast via the canal, and joining them in some dry dock near the mouth of the St. Lawrence. Notwithstanding the cost attendant upon such an operation the lake builders feel that they can compete successfully with the coast shipbuilders, and at the same time turn out a boat which would be in every respect the equal of the product of a coast yard.

In the construction of the ships which are to demonstrate the soundness of this belief, all lake precedents and methods of construction have been abandoned, and a standard type of ship has been evolved which differs in no radical way from the vessel put out by foreign or American ocean shipbuilders.

It might be thought that ships built and delivered in such a way would be designed with a view to the cutting process in order to reduce the attendant cost to a minimum, and the ship thereby weakened. Such an idea, however, is entirely erroneous, for with the exception of a limited use of snaphead rivets, which permit of easy removal, the ships were designed and built as though no such process were contemplated.

These boats are of the variety known as ocean tramps, having full lines forward but with an easy run aft to the propeller. A large proportion of dead flat permits of an effective use of the mold system which was inaugurated and perfected on the Great Lakes. The hull designs were made by the Hull Department of the American Ship Building Company, under the direction of Mr. A. C. Diericx and according to Lloyd's rules, and a special surveyor of that bureau, Mr. A. C. Heron, supervised the work of construction.



OCEAN STEAMER MINNETONKA BUILT AT CLEVELAND, OHIO.

The boats were designed pre-eminently as dividend-earners, and although the beauty feature was the last consideration it will be seen by the accompanying illustration that the designers were successful in producing a good looking and at the same time a well arranged craft. They were designed with a view to rapid and easy handling of cargo, and although no gangways are provided, this is recompensed for by the introduction of more than the usual number of hatches. Some of these are of large size to accommodate bulky freight, and are re-enforced by a removable strongback at the center. The cost of the ships to the owners is about $450,000 each.

The first of these ships, the *Minnetonka*, was success-

fully launched at the Globe yard of the American Ship Building Company, on September 14, 1901. She is a single screw steamer of 7,000 tons dead weight capacity at 24 feet draft of the following dimensions:—

Length between perpendiculars	430 ft. 0 in.
" over all	443 " 6 "
Breadth, molded	43 " 7½ "
Depth, molded to upper decks	33 " 0 "
Shear for'd	8 " 0 "
" aft	4 " 6 "
Cargo capacity	360,000 cu. ft.

The specifications are those required by Lloyds for 100 A rating, though in some cases even these requirements were exceeded.

The width of the locks of the Canadian canal restrict the molded beam of these boats to 43 feet 7 1-2 inches, and, while the depth of water over the sills of the locks is supposed to be 14 feet, at certain seasons of the year vessels drawing more than 12 feet 6 inches are unable to pass. Therefore, the designers of these boats were forced to bring the maximum depth of either of the two parts well within this limit.

There are three decks, the two upper ones being laid continuously, cut only for hatches, and the lowest having a wide stringer plate laid upon it.

The bulkheads are especially heavy and are secured to the shell by double angles.

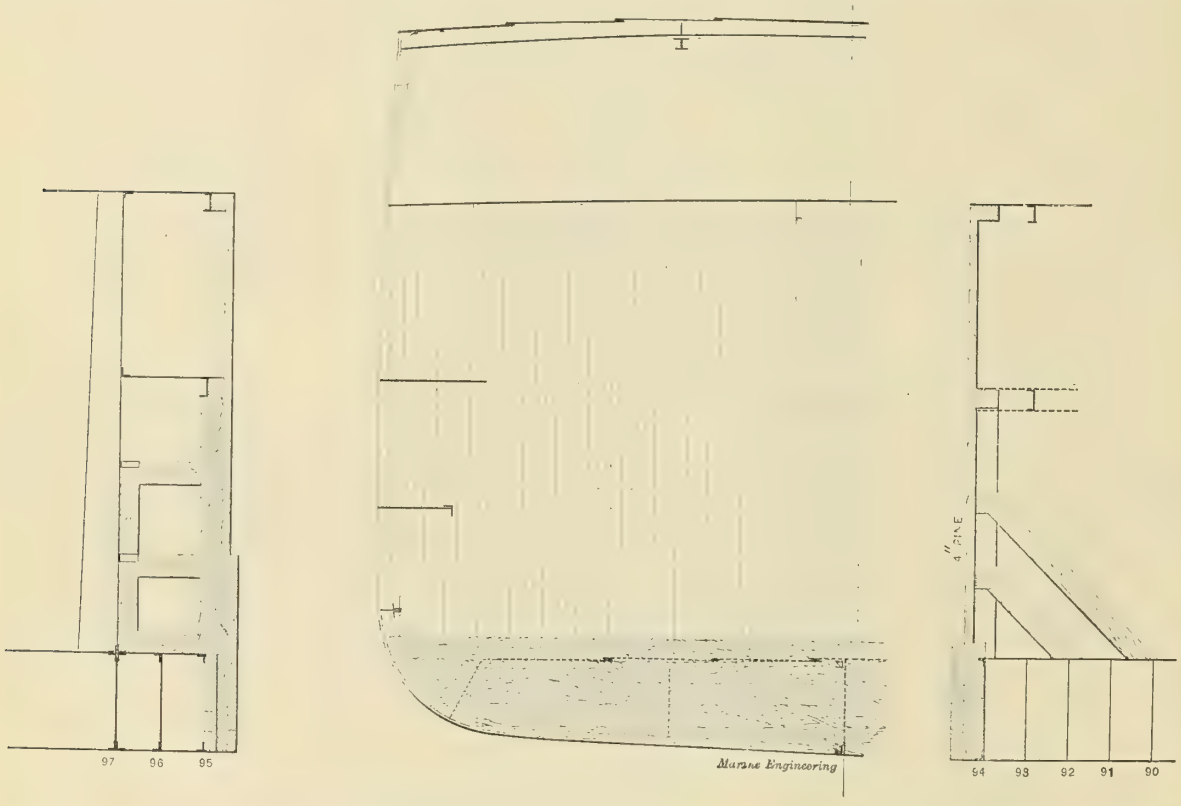
The keel is of the flat plate type 20-20 thick and treble riveted, the after end having the usual box plate formation to receive the stern post. The stem and stern post are of the best hammered scrap iron, the latter having gudgeons and stoppers wrought on.

A center continuous plate keelson, which ends at the tank top, divides the water bottom into two sections, which are in turn subdivided by watertight floors under each bulkhead.

The water bottom which extends the entire length of the ship has a capacity of 1,340 tons, and is provided with air and sounding pipes at the forward and after end of each compartment. Fore and aft peak tanks are provided having a capacity of 90 and 70 tons respectively.

The water bottom compartments under the engine and boiler spaces and for twenty-six frame spaces aft of that are used as fresh water tanks.

There are eight watertight bulkheads, all of which extend to the spar deck. The bulkheads are not cut, with the exception of the one between the engine-room and the after hold, which has a guillotine door into the shaft tunnel.



TEMPORARY WOODEN BULKHEAD FITTED FOR TOWING THE FOREBODY OF THE MINNETONKA THROUGH THE CANALS.

It will be seen by the longitudinal section that the bulkhead just forward of the boiler space extends on frame No. 97, from the tank top to the main deck, and from the main to the spar deck on frame No. 91. This was done to provide for an auxiliary coal bunker below the main deck, and to better divide the space between decks.

The deck erections consist of a steering house aft, located on the fantail, a bridge house and a forecastle. On the spar deck in the forecastle are placed the firemen's and seamen's messes, while on a deck directly below are located their respective quarters. The quarters of the rest of the crew, together with the officers' are in the bridge house. Above the bridge house are the captain's quarters, wheelhouse and bridge.

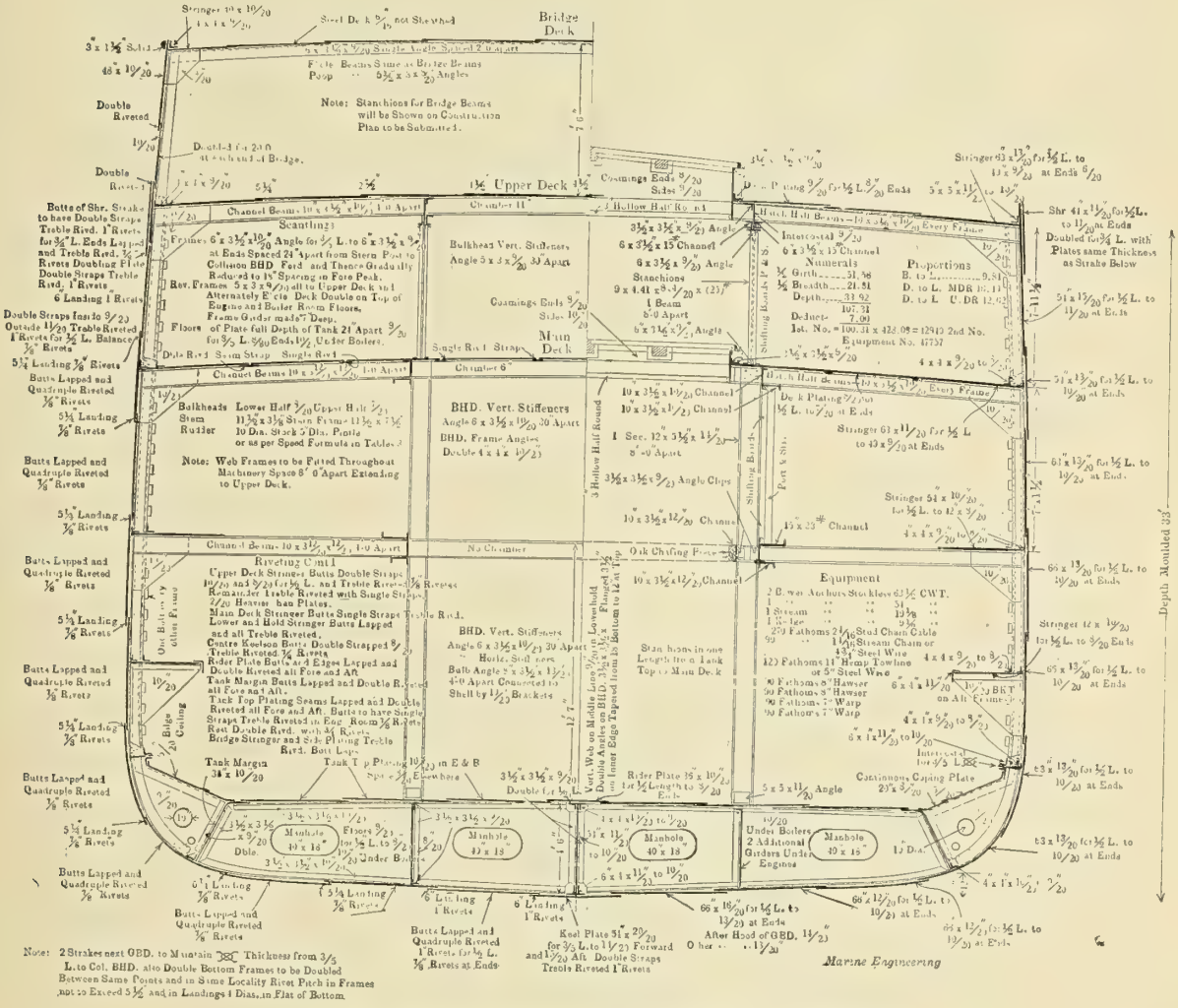
The work of loading and unloading these ships can

be carried on with exceptional facility, since two cargo booms are arranged over each hatch. The four regular masts each carry four booms, and two derrick masts are provided for hatch No. 5.

The coal bunkers are filled by means of two hatches situated just forward and aft of the stacks on the top of the bridge house, while a small hatch is arranged on the starboard side for the bunker of the donkey boiler. The ventilation of the hold is effected by bell mouth ventilators on the spar deck.

The propulsive equipment of these ships, which was designed by the Engine Department, under the direction of Mr. A. P. Rankin, consists of one 3-crank, 3-cylinder vertical inverted triple expansion engine, having cylinders 27 inches, 42 1-2 inches and 73 inches in diameter by 48 inches stroke. It was designed to give 2,400 indicated horse power at 70 revolutions per minute. This, it is estimated, will give the ship a loaded speed of 10 1-2 knots.

The arrangement of the cylinders from forward aft



MIDSHIP SECTION OF THE LAKE BUILT TRAMP STEAMERS.

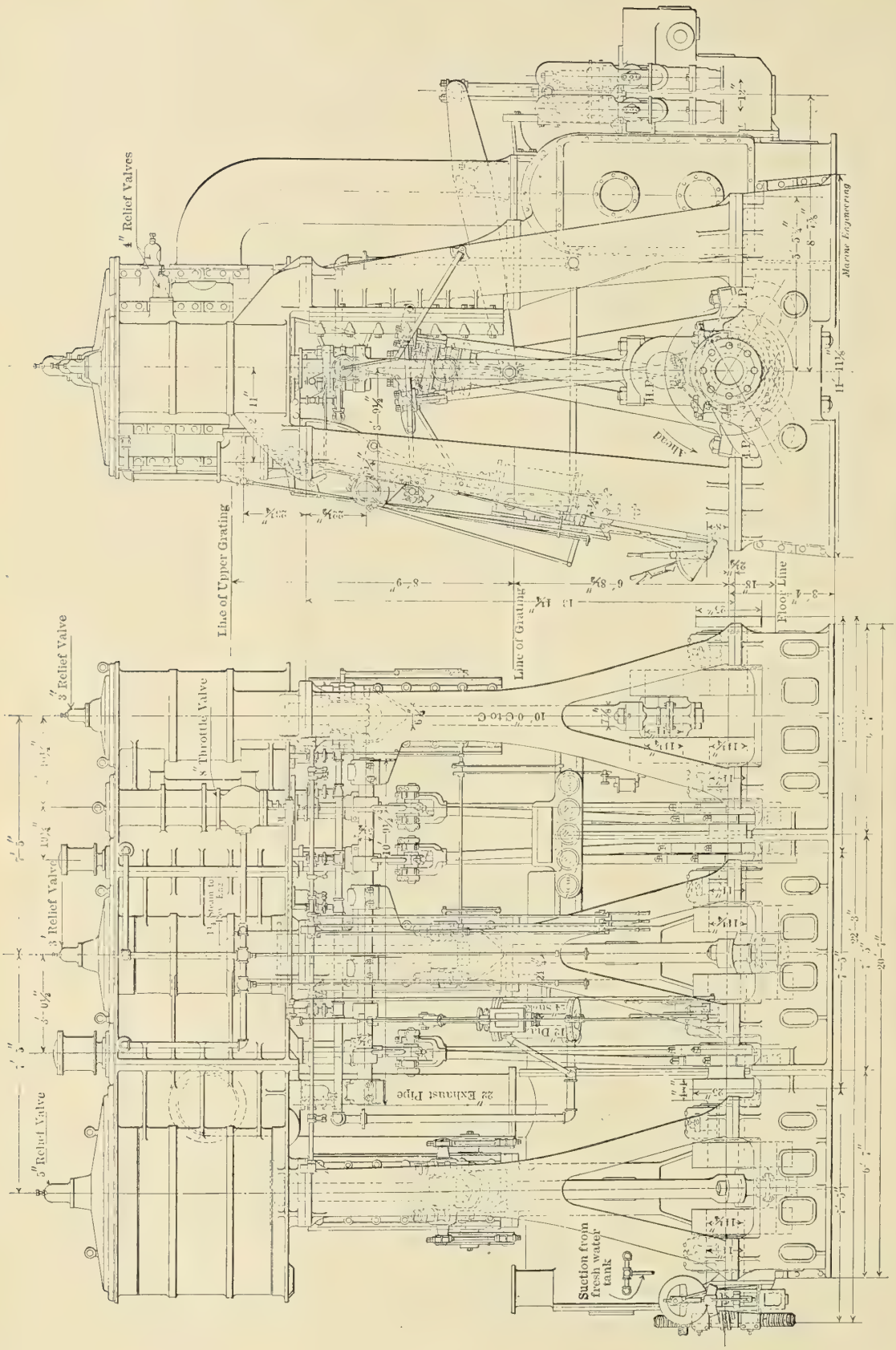
The rudder is of wrought iron frame with steel cover plates, and has the rudder stock carried above the spar deck where the quadrant is placed. The steering is located in the after projection of the bridge house on the spar deck, and is connected to the quadrant by jointed bars, which lead directly along the deck to the quadrant in the steering house aft. Coupled directly to the rudder stock also is a screw steerer placed above the quadrant. The steering engine is connected to the wheelhouse by shafting and bevel gears.

The ships have four steel masts, to each of which is fitted a triangular sail, the foremast being also provided with a foresail.

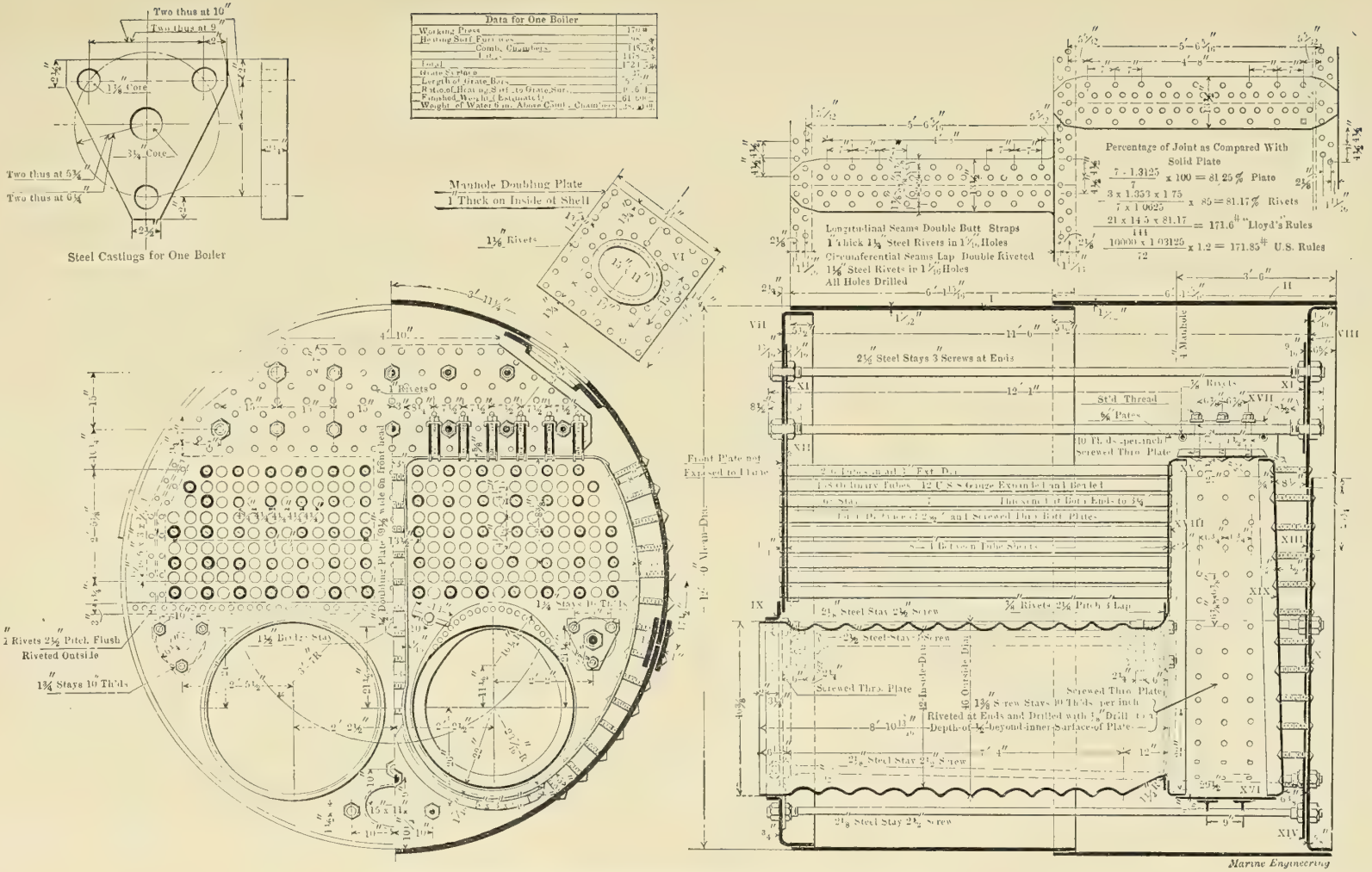
is high, intermediate and low. These are supported by six cast iron columns of box section. On the starboard side they are all bolted directly to the engine bed, but on the port side the two after ones are bolted to the top of the condenser.

The bed plate, which is of the three section box type, rests directly on the tank top, the longitudinals of the hull being arranged to take its holding down bolts. The condenser is of the rectangular ribbed pattern, and contains 3,150 square feet of cooling surface.

The valve of the high pressure cylinder is of the piston type, and that of the intermediate pressure is a double ported slide, and both are located between



TRIPLE EXPANSION ENGINES FOR THE LAKE BUILT STEAMERS MINNETONKA AND MINNEWASKA.


Two thus at 10″
Two thus at 9″
1⅛″ Core
3¼″ Core
Two thus at 5¾″
Two thus at 6¼″
Steel Castings for One Boiler
Data for One Boiler
Working Press.
Heating Surf. Furnaces
Comb. Chambers
Tubes
Total
Grate Surface
Length of Grate Bars
Ratio of Heating Surf. to Grate Sur.
Finished Weight, Estimated
Weight of Water 6 in. Above Comb. Chambers
Manhole Doubling Plate
1 Thick on Inside of Shell
1⅛″ Rivets
Longitudinal Seams Double Butt Straps
1″ thick 1⅛″ Steel Rivets in 1 1/16″ Holes
Circumferential Seams Lap Double Riveted
1⅛″ Steel Rivets in 1 1/16″ Holes
All Holes Drilled
Percentage of Joint as Compared With Solid Plate
7 - 1.3125 x 100 = 81.25% Plate
3 x 1.353 x 1.75 / 7 x 1.0625 x .85 = 81.17% Rivets
21 x 14.5 x 81.17 / 144 = 171.6# Lloyd's Rules
10000 x 1.03125 / 72 x 1.2 = 171.85# U.S. Rules
2½″ Steel Stays 3 Screws at Ends
Std Thread
⅝″ Plates
Front Plate not Exposed to Flame
Tubes
Screwed Thro. Plate
Riveted at Ends and Drilled with ⅞″ Drill
Depth of ½ beyond inner Surface of Plate
2⅛″ Steel Stay 2½″ Screw
Marine Engineering

SCOTCH BOILERS OF THE STEAMERS MINNETONKA AND MINNEWASKA.

the high pressure and intermediate pressure cylinders. The low pressure cylinder has a double ported flat valve located between the intermediate pressure and low pressure. These valves are all worked by a double bar Stephenson link motion.

The piston rods are of forged steel, having conical single thickness cast steel pistons. The crank shaft is of the built-up interchangeable type, consisting of Bethlehem steel forgings, having pins and shafts shrunk into the webs.

The crank and thrust shafts are 14 inches in diameter, joining to 13 1-4 inch tunnel shafting which terminates in a 15 1-4 inch propeller shaft.

The thrust bearing is of the horseshoe type, having eight collars on the shaft, 21 inches outside diameter.

The stern tube is cast iron, and extends from the after peak bulkhead through the stern post, terminating in a lignum vitae bearing. The propeller shaft is covered with a continuous brass liner.

The propeller is of the four bladed sectional type, with cast iron hub and blades, being 18 feet 6 inches in diameter, 17 feet pitch, and having 94 square feet of surface.

The main engine is provided with a steam turning gear on its after end, and a reversing engine bolted to its middle column on the starboard side.

There are two feed pumps, two bilge pumps and one air pump worked from the main engine, and in addition one high pressure Blake upright feed pump, one duplex donkey pump, one duplex ballast pump and one hand "Downton" pump.

A Worthington feed water heater is fitted, into which the feed water is sprayed by the attached feed pumps, and from which the independent pump takes its suction.

The battery of boilers consists of four Scotch boilers, 11 feet 6 inches long and 12 feet in diameter, each having 1,725 square feet of heating surface and 40 square feet of grate surface for each boiler. The boilers work at a pressure of 170 pounds per square inch. In addition to the main battery of boilers a donkey boiler is provided, placed on a special platform between the stacks, which has 115 pounds pressure, 40 square feet of grate surface and 1,200 square feet of heating surface.

The main steam pipe is 9 inches in diameter, and composed of extra heavy lap welded iron pipe.

The connections to the boilers are made with heavy copper pipe, having suitable expansion bends.

The Howden hot draft is used and produced by an 84-inch fan, which is in turn worked by an 8-inch by 8-inch engine. There is a bunker capacity of 800 tons in the side bunkers, and a capacity of 540 tons in an auxiliary bunker in the forward hold.

In the engine-room is installed an evaporator having a capacity of 12 tons each twenty-four hours.

The electrical equipment consists of two direct connected 10 kilowatt capacity machines, operated by vertical engines.

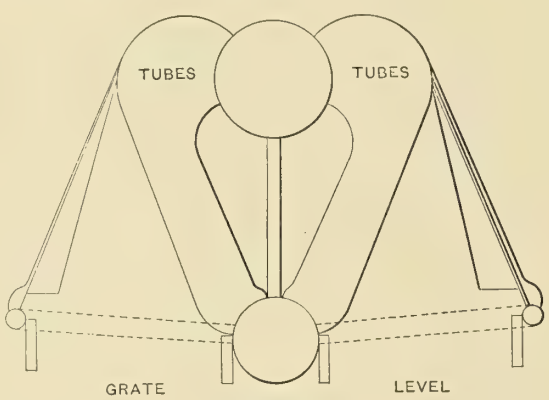
As soon as navigation opens in the spring these boats will be cut just forward of the boiler-room bulkhead, and the forward portions fitted with wooden bulkheads as shown in the illustration. Then the two portions will be towed to Montreal, there docked and connected.

Dory Launches.— Gasoline engines are being fitted into fishermen's dories at Fall River, Mass. These boats can be built at a much less figure than the ordinary launch and the equipment is satisfactory to many owners.

Monthly Shipbuilding Returns.—The Bureau of Navigation reports 74 vessels of 22,796 gross tons built in the United States and officially numbered during the month of January, 1902. The largest steel steam vessels included in these figures are the *El Alba* of 4,614 gross tons, built for the Southern Pacific Company, at Newport News, Va., and the *Spokane*, of 2,036 gross tons, built at San Francisco, Cal., for the Pacific Coast Company.

PRACTICAL POINTS IN THE ERECTION OF THE THORNYCROFT BOILER.

The Thornycroft boiler has been in use for several years for small boats, torpedo boats, yachts, etc.; but it is only recently that it has been considered as adapted for use in large vessels. A number of vessels are being built in our country in which this boiler will be installed, vessels as large as ten thousand tons displacement. The first form of this boiler had one central steam drum above and two side water drums below, between which latter was placed the grate. A slight variation of this for several boilers built in batteries omitted one lower water drum between adjacent boilers. The "Daring" type, Fig. 1, permits the combination of several boilers with a reduction in weight, space, and first cost. This type is so called from having first been used in H. M. S. *Daring*. This form has one large steam drum, one water drum directly beneath and between two grates, while on a level with and outside these grates are two horizontal pipes which play the parts of small water drums.



DARING TYPE.

Fig. 1 *Marine Engineering*

A further variation of this last type, as shown in Fig. 4, is a boiler with one central steam drum above and three water drums below, with two grates between them. These water drums are of equal size and about half the size of the steam drum. This arrangement, though heavier, permits of a large number of tubes from the outside water drums to the steam drum, and thus increases the steaming capacity of the boiler for equal weights.

The "Daring" type has a number, eight or ten, down-comer pipes to conduct the water from the steam drum to the water drum below. In the new type these pipes are used in some cases for the central drum, while large down-comers attached to the underside of the steam drum near the end lead down to the ends of the wing water drums. In another form the many down-comer pipes to the central water drum are dispensed with and a three-way "Y" casting is used with three pipes, one leading to each water drum. The description, manufacture and erection of these last types will be here given.

The steel steam and water drums are made cylindrical with hemispherical heads and all joints welded. In one head is the manhole with the edge turned in to

form the joint and to reinforce or strengthen the head. The holes are central in the heads. The drums are of mild steel and they are carefully examined for flaws, pits, holes, bad welding, thin places, or variation of curvature. They are cleaned, scraped and rubbed with heavy mineral oil and kept in a dry place till wanted.

The curved tubes are seamless, cold-drawn steel. They may be ordered bent to template. They are carefully examined for splits, pits, and uneven thickness.

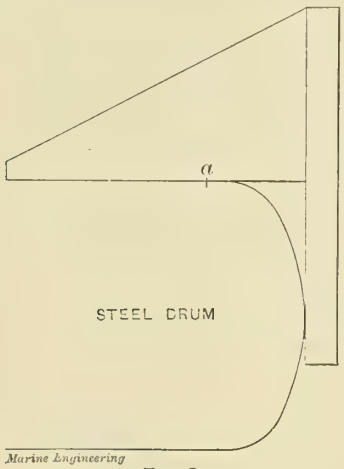


Fig. 2

In this last a slight variation is allowed, as seamless-drawn tubes are practically always slightly eccentric. A tube may have a fine hair line running lengthwise and this may indicate a sliver or split. Such a tube should be rejected.

The steel castings for the down-comer (see Fig. 5) are pickled in a solution of 5 per cent sulphuric acid, as are also the drums, before inspection. The castings should be smooth, of nearly uniform thickness, free

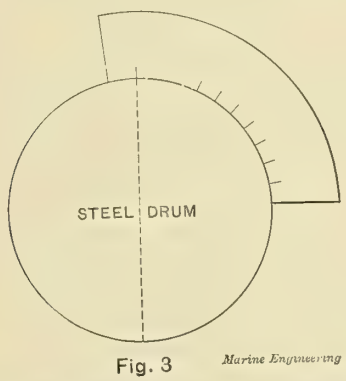


Fig. 3

from scars, holes, cracks, and of such dimensions that when machined they will be of the required size. The down-comer pipes are seamless drawn steel, free from pits, cracks, grooves, or deep blisters. The minimum thickness should be as great as that required. These pipes are pickled before examination. The flanges for these pipes are of cast steel and of such dimensions as to admit of machining to required measurements. The work of machining progresses upon several pieces at the same time.

The drums are placed in a convenient position and the holes for the small tubes are laid off. This is most easily and accurately done by centering the drum in position in a multiple drill press where it rests as in a lathe, supported by large cast iron dogs. The longitudinal welded seam is to come on top in the steam drum and on the bottom in the water drum. Full sized vertical sectional drawings are made of the boiler on a smooth floor. A template taken from this drawing showing the positions of the holes with regard to the center lines may now be applied to the drums and the lines of centers of tube holes marked off with great accuracy. A large wooden square, Fig. 2, is used to mark the position of the first holes by being placed tangent to the drum head in the drawing and then applied to the drum itself. This gives the distance of the first circumferential row from the end. A template, Fig. 3, in the form of an arc of a circle and of the diameter of the outside of the drum is laid on the drawing and the distances of the lines of centers of the holes are marked off from the center line of the drum. The intersection of these longitudinal lines and the circumferential lines as marked off by the square are the centers of the tube holes. These lines should be proved before drilling.

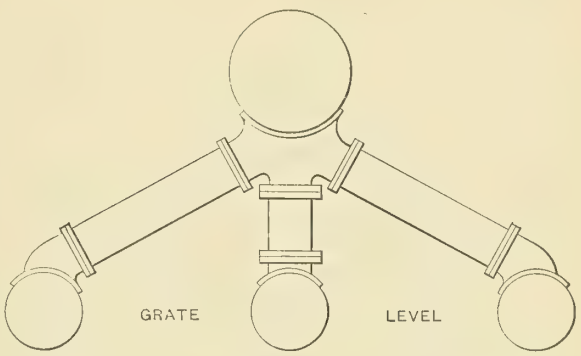


Fig. 4

A bar guide is strapped on the drum so that the first hole in the guide comes over the first tube hole position. This guide is a steel bar with one row of holes carefully laid off with distance between centers the same as between tube hole centers and with holes sufficiently large to receive steel thimbles which guide the twist drills, making holes of exactly the dimensions and distance apart required. The guide is secured firmly to the drum by two heavy iron straps around the drum. The holes should be drilled one thirty-second of an inch, smaller than full size and then reamed to the full size. It has been found that when drilled at once to the full size the surfaces of the holes are apt to be rough and grooved, especially in the steam drum which is thicker than the water drums. The line of centers of the next row of tubes is carefully laid off from the template, the drum turned and the guide bar shifted. After drilling it is better not to ream the holes till just before inserting the tubes, in order to avoid the rusting which would prevent making a tight joint.

An iron template for each different shape of tube is made from the drawing and the tubes are carefully compared with these. Most of them will require a slight bending, but those that require much should be

returned and bent again. The tubes when properly bent should not deviate from the templates more than one-eighth of an inch. The ends which fit into the drums should be accurate, for if a tube enters its hole at even a slight angle it is difficult to make a good joint. The tube ends are smoothed with emery cloth and a die driven over them to see that they are of exact size.

The holes are cut in the drums for the stops, feeds, down-comers, blows, water-gauges and safety valves,

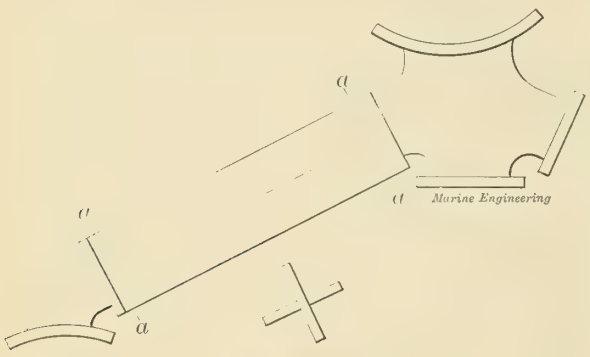


FIG. 5 AND 6.

and their positions are carefully laid off from templates taken from the full sized drawing. The surfaces of the drum around the holes are filed smooth and as cylindrical as possible.

The drums are now put into position on heavy wooden timbers and secured, steel angle distance pieces being used to hold them in relative position. The down-comer castings are then fitted.

These castings have been machined. The flange which fits against the drum has been turned off in a large boring mill and the flanges for the pipe connections in a lathe or small boring mill. The drum flange is then spot faced against the drum to a very close fit. They are then put on their respective drums and tem-

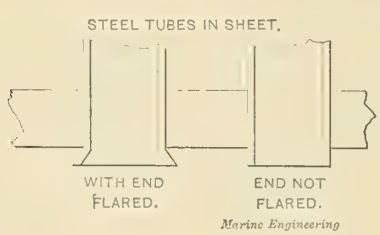


FIG. 7.

porarily bolted. It is better to not turn the pipe flanges till after the castings are bolted and fitted on the drums and these flanges can be laid off so that their surfaces are truly parallel.

To do this fit a one-half inch pine board, Fig. 5, neatly between the flanges, mark the edges of the pipe holes, find the centers on the ends of the board and draw a line through them. This will be the axis of the connecting pipe. Remove the board and fit a strip on either side wide enough to come to the edge of the flange and on the surface through line of axis. See Fig. 6. Then on the four edges of this template scribe lines in a plane perpendicular to the axis and one inch from the ends *a a*. Fit the template again snugly between the flanges and lay off along each edge a certain distance from the scribed lines. This certain distance is so taken that the least amount of metal will have to be turned off to make the pipe flange surfaces truly parallel. These four points on each flange are marked with a center punch. This operation is carried out for each down comer. The castings may now be removed and the pipe flange surfaces turned off. Marks should be made on the edge of drum flange and drum so that the casting may be accurately replaced. These castings are then riveted to their respective drums.

The boiler may be completed and tested with water pressure in the shop, in which case it is necessary to remove it bodily to and into the ship, leaving an opening in the decks large enough to allow it to pass below. Or, it may be completed in the ship, tested, and afterwards lowered on to the supports. The cold water test pressure is one and one-half times the highest working steam pressure, and it is maintained till every part of the boiler has been carefully examined. No leaks should develop, but should there be a slight weeping its importance must be judged by the inspector.

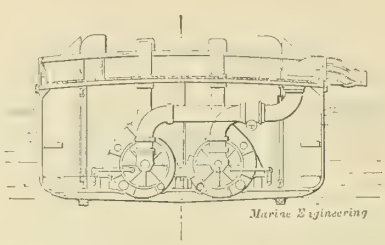
In fitting the small curved tubes in place care should be taken to have them fit accurately, not to expand them too much, and to use an abrupt taper pin to give a flare at the ends to prevent them crawling out; this taper may be one in four in diameter. They should project about one-quarter of an inch inside the drums, as shown in Fig. 7.

The fitting of the valves, the baffle plates and feed-water regulator present no difficulties outside of the usual mechanical fittings.

The casing with furnace fronts, doors, fire extinguishers and other attachments are fitted separately before being put in place over the boiler.

Dredges for Service on the Lower Seine.

The accompanying engravings are of a suction hopper dredge recently completed by the Societé Anonyme des Anciens Etablissements Satre Lyons Arles. The

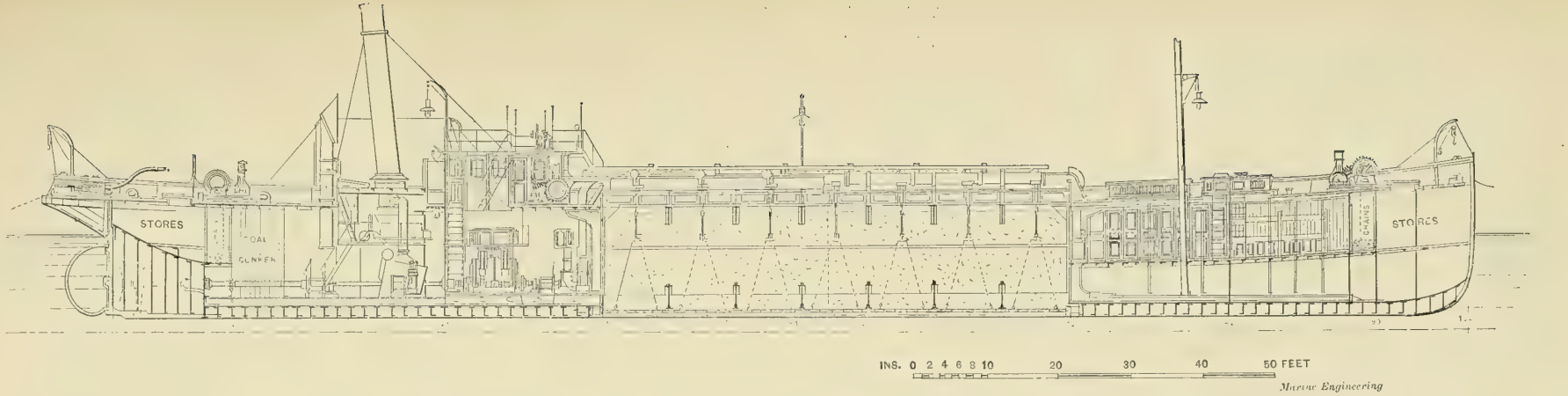


SECTION THROUGH THE ENGINE ROOM.

engravings and the following photos have been taken from *London Engineering*.

Because of shallow water in the lower Seine, navigation of the river has been restricted to vessels of light draft. It was the purpose to deepen the channel so that the larger vessels might ascend the river.

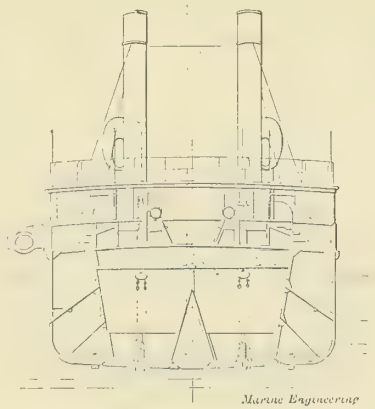
In 1895 a powerful bucket dredge was put in service, and it was found to be so efficient that further dredges



LONGITUDINAL OF SUCTION HOPPER DREDGE FOR SERVICE ON THE LOWER SEINE.

have been built. Much rough weather is encountered on the lower Seine, and, therefore, the newer dredges are constructed to operate in the seaway. The hull is divided into compartments by eight watertight bulkheads. The first compartment is the forepeak, the second is the crew space with berths for eight men, the third contains officers' cabins and one for the inspecting engineer. In the adjoining compartments are the sand and mud wells with a normal capacity of 17,658 cubic feet and a maximum capacity of 20,483 cubic feet, when extension tops are put round the openings of the hoppers. There are seven wells fitted with two pairs of doors or sluices. In the next compartment are located the engine and dredger pumps; in the adjoining one is the stokehole, and the aft compartment is used for a chain locker.

There are two sets of compound surface condensing engines with cylinders 17 5-16 and 31 1-2 inches diameter by 17 11-16 inches stroke, which develop 520 horse power with 150 revolutions. Steam is supplied by Belleville boilers, and there is a fresh water tank of capacity to supply the boilers for 75 hours. These engines can be connected to run either together or separately the two propellers or both the pumps. The pumps are centrifugal pattern, with shells cast in one piece, and provided with manholes for removing all obstacles. The suction pipe can draw sand from a depth



MIDSHIP SECTION THROUGH THE HOPPERS.

of 43 feet below water level, and can work during a rolling swell of 19 inches. The suction pipe is carried out on the starboard side, where it is connected by a universal joint to the direct pipe. The discharge from the pumps is through shutes, each with seven openings provided with sluices or doors to regulate the delivery. Double steam winches are placed on deck at both ends. Electric generators supply current for incandescent lights, and also three arc lamps are on deck.

The requirements of these dredges, which have been fulfilled, are, that they were able to draw 17,658 cubic feet of sand in fifty minutes, their traveling speed in a rolling swell of 15 inches being 8 knots, the coal consumed, 1.80 pound per indicated horse power per hour. The actual results of the test were, the hoppers were filled in thirty-eight minutes, a speed of 8 1-2 knots was reached, and the coal consumed was only 1.70 pounds.

Examination for Chief Engineer. — The United States Civil Commissioner announces that on March 25th and 26th examinations will be held at cities throughout the United States for the position of chief engineer, Class 3 in the Coast and Geodetic Survey. Persons desiring to compete should apply at once to the Commission, Washington, D. C., for application form number 304, and special forms.

Marine Engineering

Published Monthly by

MARINE ENGINEERING,
INCORPORATED

309 Broadway - - - New York.

H. L. ALDRICH, President and Treasurer.

PROF. W. F. DURAND, Advisory Editor.
F. D. HERBERT, Associate Editor.
G. SLATE, Advertising Representative.

Branch Offices.

Philadelphia, Pa., Mach'y Dept., The Bourse, S. W. Anness.
Detroit, Mich., Hodges Building, L. L. Cline.
Boston, Mass., 170 Summer St., S. I. Carpenter.

TERMS OF SUBSCRIPTION.

	Per Year.	Per Copy.
United States, Canada and Mexico	$2.00	20 cents.
Other countries in Postal Union	2.50	25 cents

Entered at New York Post Office as second-class matter.

Notice to Advertisers.

Changes to be made in copy, or in orders for advertisements, must be in our hands not later than the 15th of the month, to insure the carrying out of such instructions in the issue of the month following.

IN our last issue notice was taken of some of the questions which the marine engineer might ask himself in taking a broad survey over his field of activity. The points there noted related to the problem of the economical development of the power for the propulsion of the ship.

There are, however, many other parts of the field which will equally well repay his close attention. Thus he may note that beyond the problem of the economical development of power there lies the no less important one of its economical application to the propulsion of the ship. Here again it is a history of losses from engine to thrust bearing, where the push from the propeller is finally applied. Most of the loss is found in the propeller. Can this be reduced, and if so, to what extent? Is there likely to arise any propulsive device which shall be able to displace the propeller, and if so, what can it be? Is our present knowledge of the propeller final, or does it admit of any further improvement of moment? Again, what of the possibilities of more than one propeller on the same shaft as with steam turbine installations and what of the steam turbine itself as a rival to the steam engine? What of the efforts which are being made to perfect the balancing of the accepted type of reciprocating engine, and will their success or failure have any appreciable effect on the introduction of the turbine with its perfectly balanced running parts?

But it is not enough to study the economical development and use of power from the standpoint of the amount of fuel required per unit utilized for the propulsion of the vessel. There is an urgency equally strong toward economy in space occupied and in weight. Every extra or unnecessary ton which the machinery weighs displaces a ton of paying freight, and it must unfortunately be carried constantly about to the increase in the cost of fuel and general expense of operation. To what extent then will it be found possible to decrease the weights of machinery as at present in vogue without at the same time decreasing the margin of safety which experience demands? Will new materials be developed, will existing materials be improved, or will new combinations of old materials be found which will make possible improvements of this character?

Again, the materials which we employ are sometimes subject to waste and corrosion which seem often to be beyond our understanding or control. Likewise, the margin of safety which we deem sufficient does not always justify our judgment. Shall we learn better how to protect our materials of engineering construction from corrosion, or shall we discover new materials not subject to such chemical action, and shall we be able to better understand the play of the forces with which we have to deal and thus make our margin of safety just what is needed, but no more?

It is very sure that in the years of the present century great advances will be made in marine engineering, as in all other branches of human activity. It is safe to prophesy this, but in what directions will this progress be made? Along which of the lines mentioned above will the most notable progress be made, or will the route perchance take some direction which shall sweep aside our whole clumsy apparatus of steam boiler and engine and replace it with some more direct method of transforming energy from a natural source into mechanical work? These and all like questions the advancing years alone can answer.

THERE has been appearing in the Saturday issue of the Philadelphia Record a notable series of articles by public men on public questions. A recent paper in this series is by Rear Admiral George W. Melville, on *Naval Development During the Next Decade.*

The paper is one of strength and vigor as we should expect from the source, and we would strongly commend its careful perusal to all who are interested in these questions—we might better say to all who can read, for those who are not interested in these questions ought to be, and this article is well calculated to awaken such interest where it is lacking.

The author rehearses forcibly and clearly the general considerations which demand a navy adequate to our present needs and growing importance, and gives a statement of the various forces, educational, social and industrial, which are tending to unify our people on this point.

Taking up certain technical points Admiral Melville comes out boldly for a decrease in caliber of the heavy gun on battle ships. He is of the opinion that the ten inch gun is preferable, that the modern high powered ten inch gun having greater muzzle energy than the twelve inch of a few years ago possesses all the power which should be given to that particular part of the armament, and that the saving of weight can best be utilized by giving it to armor and to the remainder of the battery.

This recommendation is quite in agreement with the thought of many who are studying the question of naval armament, and is, furthermore, in the direct line of the developments during the decade past. We should not be in the least surprised to see in the near future battleship designs involving no gun heavier than the ten inch, and in fact in Europe designs embodying these ideas are already in progress.

Passing to other points of more especial interest to the engineer, Admiral Melville calls attention to the possible effects of heavy gun fire on the machinery outfit of a war ship, pointing out that with one hundred or more steam cylinders on board a war ship, with miles of piping, electrical conduits, etc., the shock due to the impact of a heavy shell and transmitted from the point of impact on the armor may have serious effects on much of this network of auxiliary communicaiion, and that it may not be necessary for a shell to explode within the ship to seriously disturb the operation of important auxiliaries.

The author believes that the coming decade will bring the triple screw into more common use, and that some system for burning petroleum satisfactory for war ship purposes will be devised. He also looks for an extension in the use of the steam turbine to torpedo boats and small gunboats, for further development in the water tube boiler into a satisfactory steam generator for marine purposes, and for improvements in the personnel, without which other changes and improvements will be of no avail.

WE publish on another page the more important of the recent amendments and changes in the United States Inspection Service. The importance of these rules and of the changes which are introduced from time to time at the stated meetings of the Board of Supervising Inspectors is perhaps not fully appreciated. This board and its work is the chief barrier which stands between the public at large and the danger which might arise were the design, construction, operation and management of ships left entirely to the discretion of those directly interested. While from the standpoint of higher morals and higher interest it might be thought that a reputation for safety and for attention to the interests of the public would be sufficient to insure all needful precautions, experience shows that this is not so, and that in all cases where the financial interests of employers or of corporations serving the public are not in complete accord with the interest and safety of employés or of the general public, some safeguard for the latter is needed. This has always been true of ships and shipping, and so we have on the one hand the rules of the various registration societies which require a certain standard of excellence in design and construction in order to obtain insurance on favorable terms, and on the other the rules of the Government, which take cognizance especially of all points relating to the safety of the steam machinery, to the adequacy of the equipment for saving life, and to the qualifications of officers, both on deck and in the engine and fire rooms.

The present remarks are not so much for the purpose of discussing the changes in the rules, which seem in the direction of increased efficiency and safety, but rather to call attention to the great work of this office and to its importance both to the shipbuilder and owner, and to the public which they serve.

MISHAPS AND REPAIRS.

Contribution to Prize Contest.

The last contributions entitled to be considered in the prize contest for Mishap and Repair articles were published in the February issue. Many interesting and valuable points were brought out in each article, but the article which is regarded as the best, and which secures the prize of $15, is the one written by James Wallace, published in the issue of October, 1901. The second prize of $10 goes to George H. Waring, for the article which was published in the issue of August, 1901.

All of the articles were paid for at the regular rates and these prizes are given as an additional award because of the practical value of the information given and of the skill displayed in making the repairs.

It is of so much importance that our readers exchange experiences regarding mishaps and repairs of various kinds, that we hope all who can do so, will forward statements of their experiences, accompanying them whenever possible with pencil sketches, which we will have reproduced so that the articles can be published like the others. All such articles will be paid for at the regular rates. There are very few engineers who will not benefit materially by reading of the experiences of others in handling mishaps and repair jobs.

Repairing a Broken Propeller.

During the spring of 1898 the small towboat *Josephine* broke a blade off her wheel while towing lighters at Dutch Harbor, Alaska. On attempting to run the boat with the remaining two blades the vibration was so great as to necessitate laying the boat up until another wheel could be procured, which would take about six weeks. As the stopping of the boat would be an inconvenience, I decided to repair the wheel, if possible.

Having some long timber on hand, I constructed a temporary set of ways and hauled the steamer out. I found the blade broken off 1 1-2 inches from the hub. As soon as the boat was out I took some felt paper and made a template of both sides of one of the blades, allowing for the two plates, of which the new blade was to be made to cross the hub and go up the other blades about three inches. While the helpers were taking off the wheel I cut out two pieces of 3-8 inch plate the shape of the paper template on the hand power shear that we had in camp.

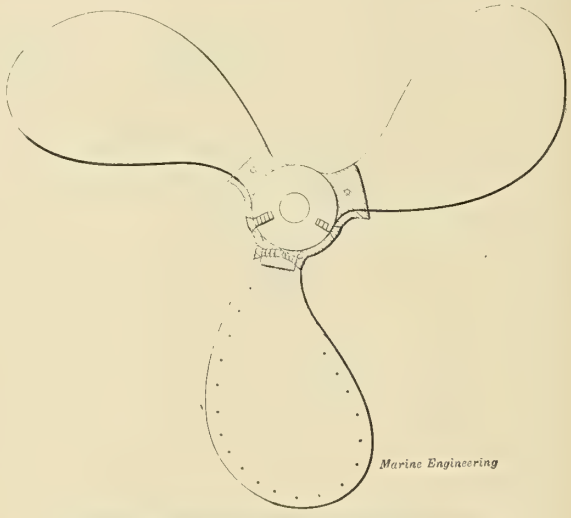
After the wheel was off I made the plates hot in a large forge and bent them to shape over one of the blades. I had chipped 3-8 inch off the sides of the stump of the broken blade to allow for the thickness of the new plates and so make the new blade the same thickness as the old one. The edges of the plates were drawn down and then bolted together, and 5-8 inch holes drilled around the edge 2 1-2 inches apart and countersunk. The blade was then riveted up.

To enable me to place the blade on the hub the same as the other blades, I bored a hole through one of the keel blocks. I then ran a pipe through the hole to correspond to the shaft, upon which we placed the wheel, and by careful measurements clamped the blade to the shaft with the same pitch as the others. We then drilled five holes on each side and put 5-8 inch tap bolts in, and our job was finished.

The engine of the *Josephine* was a single high pressure, and as there was considerable vibration I decided to fill the space between the plates of the new blade with lead and key the wheel on to the shaft, with the heavy blade opposite to the crank, as I had no material with which I could fill the blade so as to bring it the same weight as the others.

Within twenty-four hours after starting, the boat was launched and given a trial. The decrease of vibrations was very noticeable, and when last heard of the wheel was still in use on the boat at St. Michaels, Alaska.

The accompanying sketch will show the manner of fastening the plates to the hub. S. H. McL.



METHOD OF REPLACING A BROKEN BLADE.

Trouble With a Fan Engine.

It was on board one of the new breed of dogs commonly called ocean greyhounds that I had my first experience with the uncontrollable force of steam, when that giant breaks loose from its legitimate line of operation. The greyhound in question was one of the many ferry boats which oscillate pendulumlike between the old and the new world.

The boilers were fitted with Howden's system of hot forced draft, the fans and fan engines being placed directly upon the boilers, the engine, a double cylinder, double acting, being directly connected to the fan wheel, and making about four hundred turns per minute.

Walking through the fireroom on the second watch I heard a noise coming from the direction of the fan flat, and proceeding to climb the ladder leading to this earthly paradise (?) I was greeted by a terrific slamming and banging and the unwelcome roar of escaping steam. Luckily the trap door of the fan flat was closed, thus preventing the broken parts from being precipitated upon my head.

Having informed my superior of the probable state of affairs, we closed the auxiliary stop valve on the

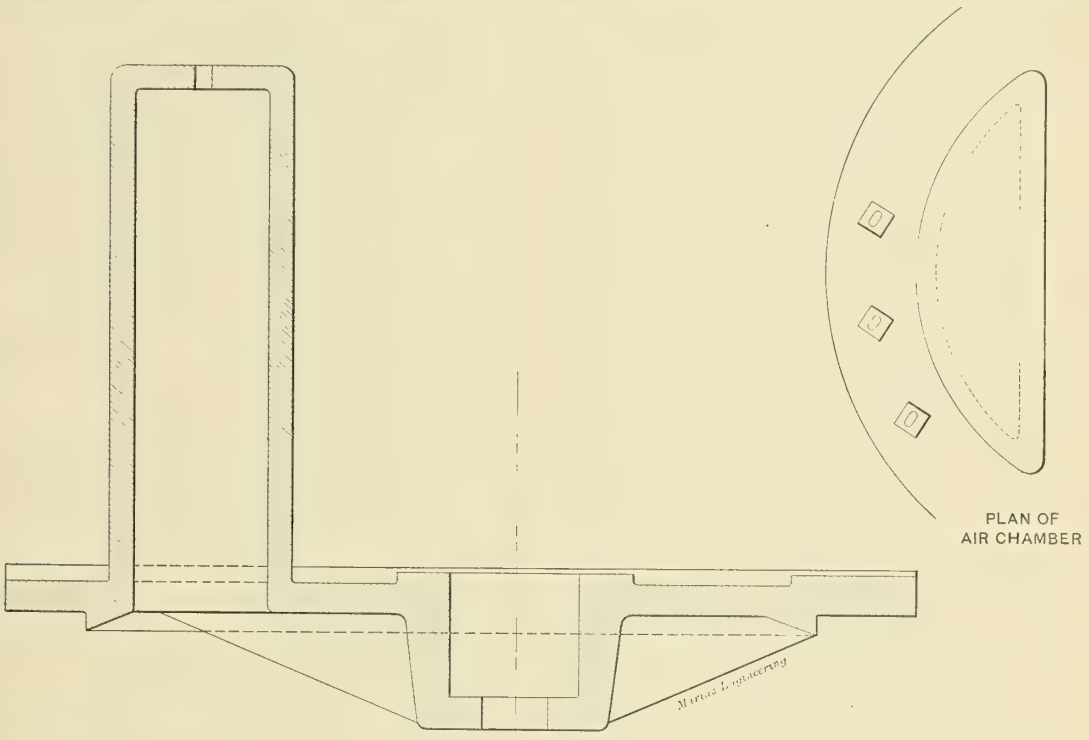
boiler so as to shut off the steam to the fan engine, and then proceeded to open the trap door of the fan flat. It took the combined strength of two men to lift it, and then we saw the effects of the ill-directed efforts of the steam.

First shutting off the exhaust valve on the engine we found the following damage. The shaft had broken off short in the crank web, the crank pin brass bolts on both connecting rods were broken, and the engine still taking steam for one or more revolutions had lifted the covers off both cylinders, carrying away the studs and portions of the cylinder castings.

Both piston rods were bent, as were also the connecting rods, eccentric rods and valve stems.

asbestos cloth being forced in with them. The jacks were screwed hard down and remained in place, thus obviating the necessity of the studs.

The exhaust valve was then opened, the steam stop on boiler opened and the engine was started, not blowing anywhere, and again making 400 turns, and ran this way for four days, until we reached the dock in New York, the only thing necessary being the occasional tightening of the screw jacks. The whole job was done in 8 1-2 hours from the time of stopping the engine until the starting of the same, which shows what can be done in a well appointed ship where the owners do not save at the wrong end, i. e., in the engine room help. X. Z. Y.



AIR PUMP COVER WITH AIR CHAMBER.

Ocean greyhounds are well supplied with engineers, and the job in question did not present any great difficulty except the fact that the temperature in the fan room was about 145 degrees Fah., and all the pieces were hot.

Four engineers and oilers now proceeded to get the broken and bent parts of the engine out, also the shaft out of the fan wheel, while another force of men got out a spare shaft and proceeded to fit the bottom end brasses, eccentric and eccentric sheave.

When all this had been done, the new shaft was put into place, the new connecting rods were put up, new piston and piston rods put in, and everything went well, until we came to put on the cylinder covers. The old ones having been smashed to pieces and the top part of the cylinders and studs having been carried away, a piece of 1-16-inch asbestos cloth was laid over the cylinders, new covers put on, and then two screw jacks braced against the upper deck, and acting on the covers, forced them into the counterbore, the

Broken Air Pump Links.

When the United States Dynamite Gunboat *Vesuvius* was completed, she represented at that time (1888) the highest type in the development of marine engineering in this country. The contract requirements were that she should develop a speed of not less than 20 knots over a measured course of 2 1-2 miles. Before this speed was attained four or five unsuccessful attempts were made. On two of the preliminary trials breakdowns of a more or less serious nature occurred in the middle of the run.

The engines are of the 4-cylinder triple expansion type having cylinders of 21 1-2 inches, 31 inches and two 34 inches in diameter respectively, by 20 inches stroke. The two low pressure cylinders on each engine were forward, and an air pump at the back of each low pressure cylinder was worked by the ordinary plate steel beams connected by links to the low pressure crossheads. One trial trip had been run with the air pumps working successfully, but in the middle of

the second trial, while the main engines were making 260 revolutions per minute, there came a crash which could be heard above the din in the engine room. In the vicinity of the forward low pressure cylinder on the starboard engine, a shower of sparks could be seen.

The engine was stopped as quickly as possible and the cause of the pyrotechnic display was soon apparent. The air pump beams had both broken off about 12 inches from the ends to which the links from the crosshead were attached. At the high rate of speed the engine was running the broken ends had been whirled around at a terrific rate, striking the guides at each revolution. One of the oilers happened to be directly in front of this cylinder when the break occurred but, most providentially, was only slightly injured. The broken end of one of the links knocked an oil can out of his hand, and tore off one of his finger nails. An investigation was made and it was found that the accident was due to a solid rush of water from the condenser to the air pump. The top cover of the pump was also found to be broken.

The broken ends of the beams and the links were disconnected from the crosshead, and the ship returned to the city running at half speed and using, of course, only one air pump on the starboard engine. In order to avoid a repetition of this accident, new top covers were fitted to the air pumps, each with an air chamber cast with the cover as shown in the accompanying sketch.

On all the subsequent trials no further trouble was found with the working of these pumps and, so far as I know, these air chambers are fitted to the pumps yet. In modern practice the fitting of the discharge valve plate as a sort of a "floating top" precludes the possibility of a similar accident from a rush of water.

C. Albert.

An Engine Breakdown.

The steamer *Balance* was one of those crafts, which, instead of navigating the bosom of the ocean, ought to have been safely lodged in Davy Jones' locker long ere this, and the fact that she still defied the laws of navigation and gravitation was due more to the unselfish efforts of the men who incautiously ventured to ship in her, than to the efforts of the owner.

She was a compound job, with cylinders 22 1-2 inches and 60 inches by 36-inch stroke, steam 140 pounds, and turning a right-hand wheel at 60 revolutions per minute.

Rushing through the Cuban waters, bound for New York at the magnificent speed of ten knots, the engineer on watch was disturbed in his pleasant dreams of home and the time when he could leave this floating graveyard, by a terrific crash, and instinctively rushing to the engine throttle, he shut off steam, but in spite of his celerity the engine made another revolution and completed the wreck.

The engine-room was filled with steam and flying pieces of iron and steel. It wasn't necessary to call the chief, since he was at that moment coming down the engine-room ladder. So leaving the chief to give orders, the engineer on watch rushed into the fire-room, closed the stack damper, opened his fire doors and eased the safety valves, and then returned to the engine-room to find out the result of the engine's strange maneuvers.

The crank-pin bolt on the low pressure engine had broken on the up stroke, and one bolt being insufficient to hold the strain, had given way, and the piston rod and connecting rod in their upward course had fractured the cylinder cover. The engine still turning, due to the high pressure engine, the free end of the connecting rod came down, and swinging against the condenser knocked a big hole into it. The engine still turning, the low pressure piston again went upward, and striking the cracked cylinder cover completed its work and made the pieces fly in all directions.

By this time the engineer on watch had succeeded in stopping the engine, and the engine staff now proceeded to make repairs.

The hole in the condenser did not present any material difficulty. Luckily none of the tubes were broken, so the necessity of taking off the condenser covers and plugging up the broken tubes was obviated. Four holes for studs were tapped into the condenser around the hole, and a joint was made with red lead putty and rubber packing, and a board bolted over the whole thing.

The engine, however, was in bad shape, the broken crank pin bolt showed flaws in the forging, the cylinder cover was broken beyond repair, so the chief decided to go into port under the high pressure engine only.

The air pump and the circulating pump being driven off the low pressure cross head, spare crank pin bolts were put into the crank pin brasses, and these connected to the low pressure connecting rod, thus giving motion to the air and circulating pumps.

This piston rod was released from the cross head, the piston raised from the cylinder and lashed to the top of the engine. The low pressure valve chest cover was taken off, the low pressure valve taken off the stem, and the men getting into the valve chest proceeded to fill up the ports by means of wooden wedges, caulking in between the pieces with lamp wick and white lead.

Then the eccentric straps were taken off the low pressure engine, the valve stem blocked up and fastened, the low pressure valve chest cover put on, the steam in the boilers reduced to 80 pounds, and away we went at a 7-knot gait. It was necessary to stop the engines twice on the way to New York to drive back the wooden wedges in the ports, as they showed a tendency to get loose, due to the atmospheric pressure.

The exhaust from the high pressure cylinder passed into the low pressure valve chest and then went directly to the condenser, which maintained a vacuum of 21 inches.

When the vessel arrived at New York, a new cylinder cover was made, and the engine was as good as new. The whole time of stoppage during the time of making repairs was 54 1-2 hours, and due to the fact that the engine-room force was limited to a small number of men, the job was a very creditable one, and the chief was highly commended for his ingenuity and perseverance.

A. B. C.

COMMUNICATIONS.

Robert Fulton.

Editor of Marine Engineering:

Reverting to your article on the "Robert Fulton Memorial" in the January issue, I, in connection with many other of your readers, would like to know the chronological position occupied by the *Clermont* in the history of the steamship. This desire is suggested the more by your statement in the article named that "it is not claimed for Fulton that he invented the steamship," while in the preceding paragraph to that in which this occurs you say, "This trip of the *Clermont* demonstrates that it was thoroughly practicable to use steam power for propelling vessels." These quotations don't seemingly agree, because if the *Clermont* was the first boat to demonstrate the practicability of using steam as a propellant, then Fulton invented the steamship. But as this trial trip happened in 1807 and we have authentic records of a similar trip having been made in 1802 equally as successful as the one referred to, it is difficult to find the basis for the claim made in Fulton's behalf. It is well known that one William Symmington constructed a steam tug boat named the *Charlotte Dundas* and had a successful run with her on the Firth of Clyde canal, Scotland, in 1802, or five years previous to Fulton's effort, and I have always understood that this was the first steamer constructed.

Navis.

In reply to the above communication, we would refer readers who are interested in the early history of the steamboat to the "Growth of the Steam Engine," by Prof. R. H. Thurston, in which will be found in chronological order, the various experiments of early inventors of steam engines and historical information.

To briefly answer the above question, we would state that, like the steam engine, it is impossible to ascribe to any one man the invention of the steamboat. James Watt was the first to make the steam engine a commercial success, yet his invention is the growth of many years of study by himself and early inventors.

In 1707 Papin applied a steam pumping engine for propelling boats on the river Fulda. He later petitioned the Counsellors of Hanover to allow the steamboat which he proposed to build to navigate the waters of the Fulda. Permission, however, was not granted. In 1736 Jonathan Hulls took out in England a patent for the use of the steam engine for ship propulsion and towing. However, it is uncertain that his plans were ever carried out.

The French Academy of Science offered a prize in 1752 for the best essay on the manner of impelling a vessel without wind. This elicited several remarkable papers. In one of them is found a description of a proposed wheel like a wind mill, one to be placed on each side of the vessel and several more behind. In this we may see the embryo of the modern screw. Another proposed to use the Newcomen engine for ship propulsion.

In France the Marquis Jouffrey was one of the earliest to see in Watt's improvements of the steam engine its applicability for the propulsion of vessels. A company was formed and the first vessel was commenced in 1772. However, shortly before completion, the vessel sank and the experiments were discontinued for a time. Another boat was built by Pierre and a trial trip made in 1774 on the Seine with unsatisfactory results. At a public trial of a boat 140 feet long, built by Jouffrey in 1783, some degree of success was attained, but owing to the fact that the National Academy did not indorse the invention, further attempts were given up.

Returning to this country, mention should be made of William Henry, who, on returning from England in 1763, where he met James Watt, placed a small engine in a boat and made a trip on the Conestoga river near Lancaster, Pa. John Fitch was an acquaintance of Henry's and we find that Robert Fulton was also a guest of Mr. Henry in 1785. Fitch produced several small boats propelled by steam, and in one of these is found the first form of paddle wheel. He later built larger vessels, and in July, 1788, made the trip from Burlington to Philadelphia, a distance of twenty miles. As the boilers of this boat gave out, however, she did not prove a success. Fitch continued his experiments and in 1796 he built a small screw steamboat at New York city.

Mention should be made of William Symmington, Patrick Miller, James Taylor, Samuel Morey, Nathan Reed and Elisha Ormsby for their more or less successful attempts at propelling vessels by steam. Lord Dundas became interested in this subject and engaged Symmington in 1801 to build a boat for him which he named the *Charlotte Dundas*. She was propelled by a double acting Watt engine turning a crank with a paddle wheel shaft. After one trip, however, this boat was laid up and we hear nothing more of her. Ten years later Henry Bell constructed the *Comet*, the first passenger vessel built in Europe. She was of 30 tons burden, 40 feet in length, and 10 1-2 feet broad.

From the above facts it is evident that from various causes marine propulsion had not been successful prior to Robert Fulton's time. Many inventors had gone down because of lack of capital to carry out their experiments and construct their apparatus, and in no way would we belittle Fulton's achievements because of the assistance of Robert Livingston. Therefore we can reserve for Fulton the place of honor in the early history of marine engineering. Editor.

Caulking Liners on Propeller Shafts.

Editor of Marine Engineering:

In your December issue I notice a very interesting article on propeller shafts, by Mr. H. F. J. Porter. I fully agree with Mr. Porter that in most cases the fracture of the propeller shaft is due to galvanic action, set up by the steel shaft and the brass sleeves. In the following illustrations I offer to your readers a design which has been used by me successfully in a good many cases.

The object of this design is to separate the two hostile metals entirely, where they are in touch with salt water.

Fig. 1 shows the end of a 12-inch tail shaft nearest to the coupling. *S* is the shaft, which is enlarged where the sleeve is fitted; *B* is the brass sleeve which is allowed to extend on both ends, the bore being dovetailed inwardly as shown, and into the recess thus formed, lead or tin is poured as shown at *A*. After

cooling, this soft metal is well caulked, so it will be perfectly watertight, thus separating the edge of the sleeve from the shaft.

Fig. 2 shows the end of the tail shaft containing the hub of the propeller. Wherever an iron or steel propeller is used, the hub has to be protected from galvanic action as well as the shaft. The forward end of the hub is fitted with a dovetailed recess which projects over the end of the brass sleeve; the latter is reduced at this end to fit the smaller diameter of the shaft, and the shoulder thus formed slightly dovetailed to assist in holding the lead, which is poured into the recess and afterwards caulked.

In the case of the shaft shown in the illustration, the ends of the sleeves were tinned first, causing the metal to stick to it as if it were a soldered joint.

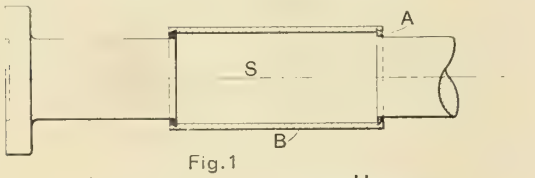


Fig.1

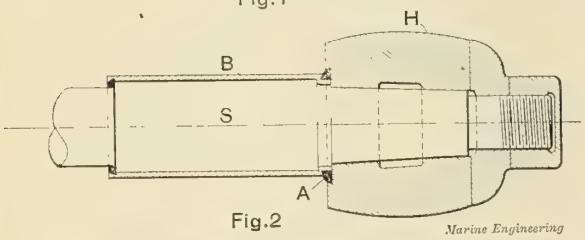


Fig.2

Marine Engineering

The lead should be caulked before the sleeve receives its finishing cut, as the caulking will expand the ends slightly. This shaft was fitted into the steamer *President Boers*, which is plying between Banjermassin and Makassar, in Dutch East India, where the water has a particularly destructive effect on tail shafts. It has been in service for over ten years, but according to the last information I received about it, some three or four months ago, has thus far shown no defects.

When galvanic action attacks a tail shaft, besides the metal that is eaten away, the material which might appear solid is crystallized over a considerable space, thus weakening the shaft considerably.

H. E. Raabe.

LAUNCHES.

Submarine Boat Plunger.—The *Plunger*, the sixth of the submarine torpedo boats built at the Crescent Shipyard, Elizabethport, N. J., was launched on February 1st.

Steamer A. G. Brower.—The steamer *A. G. Brower*, belonging to the United States Transportation Company and built for the iron, ore and grain trade, was launched from the South Chicago yard of the American Shipbuilding Company on December 28. The new boat is 346 feet long, 48 feet beam and 26 feet deep.

Steamer Romona.—The steamer *Romona*, belonging to the Pacific Coast Steamship Company, was launched from Dickie's yard, Alameda, Cal., on December 24. The dimensions are: Length over all, 210 feet, between perpendiculars, 200 feet; beam, 32 feet; draft, 11 feet. She is built for the freight and passenger trade between San Francisco and San Pedro and has handsome accommodations for 150 passengers.

Steamer Minnewaska.—The steamer *Minnewaska*, which is owned by Eastern capitalists represented by C. E. and W. F. Peck and built for ocean trade, was launched from the Cleveland, Ohio, yard of the American Shipbuilding Company on December 21.

Steamer Western States.—The *Western States*, the new Cleveland and Buffalo Transport Company's passenger steamer, was successfully launched at the Wyandotte (Mich.) yard of the American Shipbuilding Company, on January 19th. The *Western States* is a sister ship to the *Eastern States*, which was launched in December, 1901, and her principal dimensions are length on water line, 365 feet, breadth 45 feet, molded depth 20 feet.

Steamship Kroonland. — On February 8th the steamship *Kroonland*, built for the International Navigation Company, was launched from the shipyard of Wm. Cramp and Sons' Ship and Engine Building Company, Philadelphia, Pa. The dimensions of the *Kroonland* are: Length between perpendiculars, 560 feet; length over all, 600 feet; beam molded, 60 feet; molded depth, 42 feet. On a draft of 26 feet the hull displaces 18,000 tons. The gross registered tonnage is 12,000.

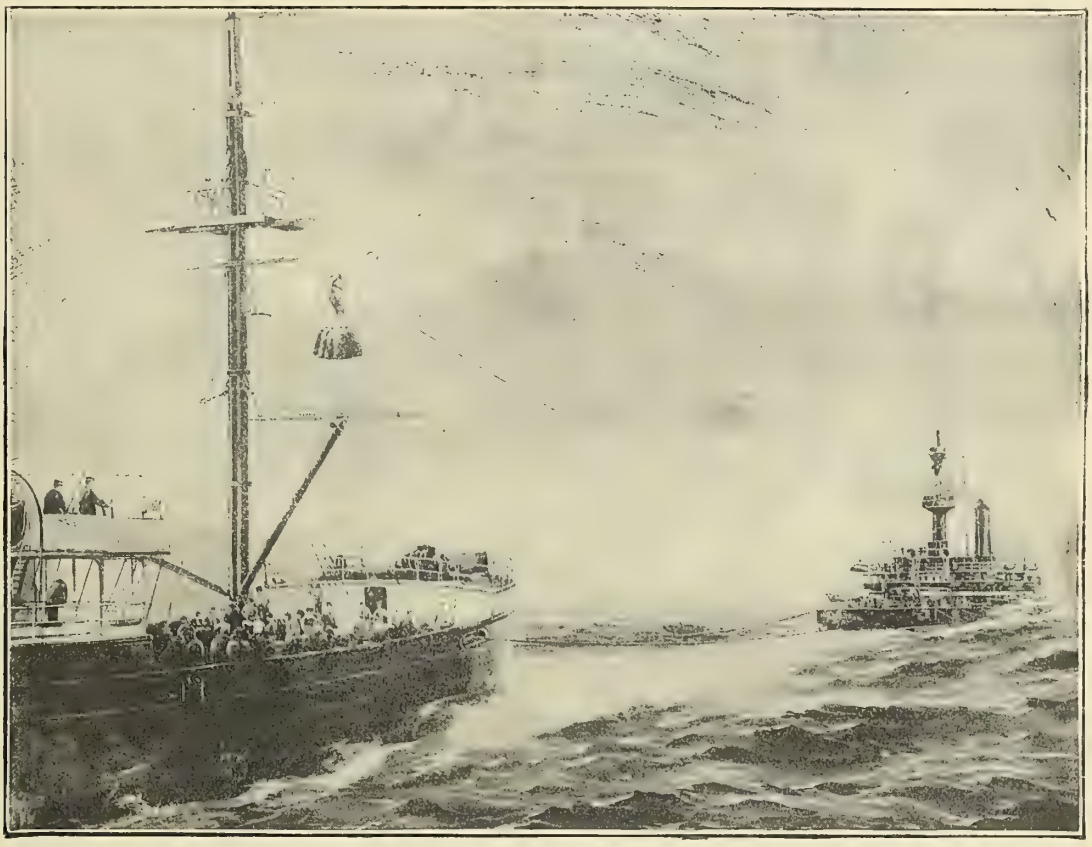
Steamship Nevadan.—The *Nevadan*, the first of the three vessels which the New York Shipbuilding Company is constructing for the American-Hawaiian Steamship Company, was launched at Camden, on January 22d. The *Nevadan* is built for service between New York and San Francisco, and is of the following dimensions: Length, 371 feet; beam, 46 feet; depth of hold, 34 feet; dead weight carrying capacity about 5,300 tons. The boilers are fitted for using oil fuel or coal.

Battleship Missouri. — On December 28th the United States battleship *Missouri*, a sister ship to the *Maine* and *Ohio*, was launched from the yard of the Newport News Shipbuilding and Dry Dock Company. The keel was laid February 7, 1900, and the contract price was $2,885,000. The dimensions of the *Missouri* are: Length on water line, 388 feet; extreme breadth, 72 feet 2 1-2 inches; mean draft, 23 feet 6 inches; corresponding displacement, 12,230 tons. A side belt of armor extends from the bridge, where it is 4 inches, to the after end of the second casement. Amidship this belt is 11 inches maximum. Above this the sides are protected by 6-inch armor. There are two turrets, with 12-inch armor, mounted on barbettes with armor of the same thickness. The armament consists of four 12-inch 40 caliber, sixteen 6-inch 50 caliber rapid fire guns, six 3-inch rapid fire, eight 6-pounders, six 1-pounders, two Colts and two 3-inch field guns. There are two submerged torpedo tubes. The contract speed is 18 knots. She is propelled by two sets of twin screw triple expansion four cylinder engines, with a collective horse power of 16,000. The diameter of the cylinders is high pressure 34.75, intermediate 53, low (two) 63 inch, with a common stroke of 48 inches. Steam will be supplied by twelve Thornycroft boilers, with total grate surface of 1,000 square feet and a heating surface of 51,372 square feet. The complement of officers and men will be 551.

ENGINEERING SPECIALTIES.

Successful Test of Coaling at Sea by British Admiralty.

Important news comes from England of the complete success of the sea trials recently undertaken by the British Admiralty in coaling warships at sea with the marine cableway. The Lidgerwood Miller Marine Cableway will shortly be tested on one of the United States battleships preparatory to its general adoption by the Government, and Russia has already applied it to the latest of its great battleships, now building in this country at the Cramp yards, Philadelphia, Pa. Whatever difficulties may have been encountered heretofore in the perfect working of the device have clearly been overcome in the most satisfactory manner in the latest form of the cableway as perfected by Spencer Miller, the inventor. More than this, its capacity has been increased to a degree which will enable it to give the maximum service desired. All of this is strikingly shown in the test abroad, just completed. It will be remembered that in the trials made by the United States Navy Department it was required that the cableway transfer twenty tons of coal an hour with a distance of 300 feet between ships speeding at the rate of six knots. This was successfully accomplished in a heavy seaway. In the test by the British Admiralty the required amount to be transferred was increased to forty tons per hour, and the distance between ships to 400 feet (making for greater safety), while the speed of the vessels was almost doubled. The official test made off Portsmouth, in the English Channel, on the 4th inst., with the batttleship *Trafalgar* and collier *Muriel* in tow, lasted three hours, and developed a maximum of forty tons of coal transferred per hour. The engraving below shows the two vessels while making the test, and gives a good idea of the working of the marine cableway. The pair of sheaves which was formerly required upon the after deck of the towing vessel, and a canvas chute down which the bags of coal were dropped, has now been done away with. When the load of bags reaches a point in transit immediately over the after deck of the receiving vessel all the cables are pulled down to the deck, the loaded bags deposited, the empty ones hooked on and the cables tautened up again and the traveler returned. In the test by the British Admiralty a large square mast was fitted in the fore part of the collier *Muriel*, and from the top of this the cableway extended to the quarter deck of the *Trafalgar*. An elevator runs on rails secured to this mast and hoists a ton of coal in bags 65 feet to the masthead. A traveling carriage takes the coal bags from the elevator and transfers them at great speed to the warship. A trip every minute is easily accomplished. The traveler is propelled back and forth by a wire rope 1-2-inch in diameter, operated by two direct acting engines having two 10 by 10 inch cylinders, and slipping drums. Instead of using a sea anchor to keep an equal strain on the main cable be-



BRITISH BATTLESHIP TRAFALGAR COALING AT SEA.

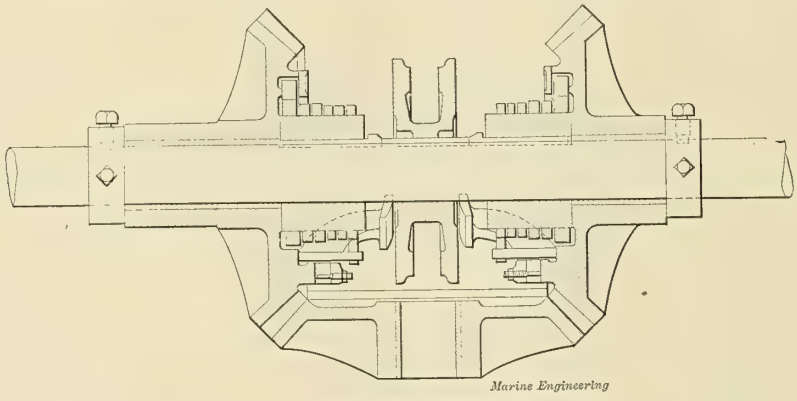
tween the vessels, the same result was ingeniously accomplished by the use of a main cable tension engine, which automatically keeps the cable taut while permitting its length to vary. This engine has two 13 by 13 inch steam cylinders, and is geared to a slipping drum. The engine turns in the same direction all the time, and the slipping drum is given a definite power of about five tons by the slip of its friction heads. Hence the drum maintains a constant pull on the main cable, revolving one way and then the other, as the movement of the ships requires greater or less length of cable. The apparatus is made by the Lidgerwood Manufacturing Company, 96 Liberty street, New York.

The Coil Clutch.

The illustration shows a reversing gear applicable to marine engines as made by the Coil Clutch Manufacturing Co., 45 Broadway, New York, by the adaptation of the B type of Lindsay's patent clutches. The arrangement consists of three bevel gears, two running loose on the propeller shaft and in opposite directions through the third gear as an idler. The motion is communicated from the engine to the gears by a spur wheel keyed on the extended hub of the bevel.

The necessary changes to obtain reversal in either direction are made by means of two clutches. The coil of each is rigidly connected at one end to the bevel gear. The coils are wound around chilled iron drums, keyed to the propeller shaft, and in opposite directions, so that the tendency is to tighten itself when any drag is put on the point or either coil to give an initial grip. When this clutch holds, the gear and propeller shaft become connected, the power is transmitted directly from the engine and motion is communicated in the direction of the corresponding gear. The clutches are manipulated through a lever sliding a double-faced disc along the shaft, which presses either face against a bellcrank lever, which tightens the corresponding coil. A small lever is pivoted on a stud carried from the boss of the gear wheel, and its end projects so that the sliding disc, operated by the clutch lever comes against it. When this is done a projection of the lever comes against an adjustable stop on the end of the coil, and slightly tightens its convolutions. The smallest movement causes the coil to wind itself up and obtain a grip on the chilled boss or sleeves on which it is wound, of such exceeding tightness that it will transmit thousands of horse power. These clutches are made from one horse power to ten thousand horse power for reversing arrangements for propeller shafts, machinery of all kinds and rolling mills. A pair are now being installed at Moscow, Russia, of 12,000 horse power, weighing 127 tons complete. So perfect is the control exercised by the starting gear that the clutches can be started quite gradually, and if desirable, permitted to slip, or they can also be stopped and started as easily, with or without the full working load.

The coils are forged steel bars, gradually tapering toward the point and are wound into helices. The varying section supplies the strength of the part where it is needed, and renders the coil more elastic and delicate in action. Immediately the pressure is released from the coil it liberates itself, while the moment it is pressed it takes up its work without noise or shock. As an evidence of the extreme delicacy of coil clutches, mention may be made of the fact that the same coil will act both as a clutch and a brake.



A NEW COIL CLUTCH.

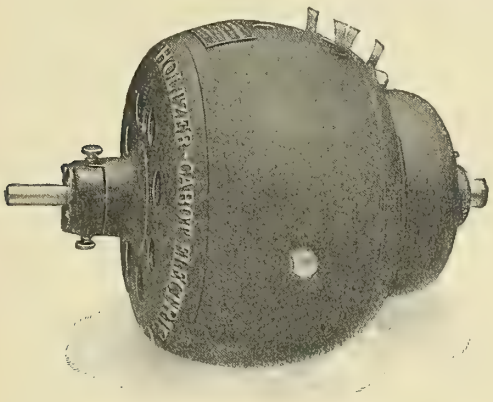
For all general purposes which include hoisting appliances, the B clutch is used singly, or two other types, D and G, built on the same general lines but somewhat modified. The principal as illustrated above governs the working of all these various types.

Electric Motors for Launches.

Navigation is one of the latest fields to be invaded by electricity, and now small launches, and even rowboats, are being driven by electric motors in an entirely satisfactory manner. In the accompanying illustration is shown a half-horse power motor, which is one of a line constructed especially for launch work. As will be observed, the motor is entirely enclosed, being practically moisture proof. If the motor is well protected, or is to be used in fresh water, the weight is materially decreased by the use of aluminum parts where other metals are not necessary for electrical or magnetic purposes; although, if the motor is likely to be exposed to the salt water, brass or iron fittings are recommended, because of the corrosive action of the salt water upon the aluminum. In the latter case the finished parts of the machine are copper plated for the same reason. The shape of the frame is such that two

equal paths are provided for the magnetic flux, one on either side of the armature, a design which allows of great compactness.

As the voltage is low, the current is proportionately large, making the design of the brush holder a feature of great importance. The brush holder used with these motors is of the box type with parallel feed, making it possible to run the motor for a long period of time without any attention to the brushes. A special form of brush is used, consisting of stratifications of woven copper gauze and carbon, the outside layers being of the latter substance with a heavy copper plate. In this way are secured the advantages of the high conductivity of the copper and the wearing qualities of the carbon, the latter also preventing the copper gauze from spreading out and sticking in the holder. A continuous metallic circuit is maintained between the brush and the holder, so that no sliding or imperfect contacts are required to carry current. This



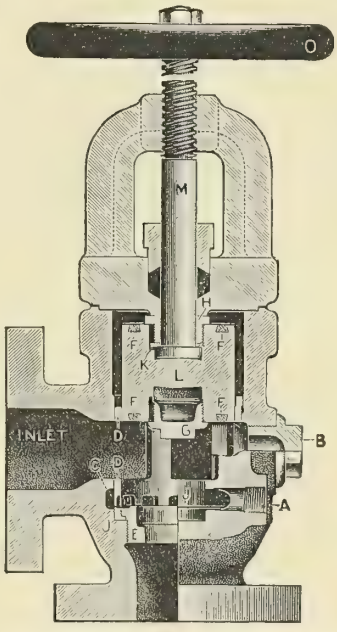
AN ELECTRIC MOTOR FOR LAUNCHES.

makes an extremely efficient and satisfactory brush arrangement for work of this kind, allowing long wear with minimum attention and making heat losses due to the flow of the current insignificant.

The machines are very economical in operation. The speed is low, 1,000 R. P. M., and as they are series wound they use field energy only in proportion to the load, thus modifying two of the most important sources of waste, namely, friction and heat losses in the windings. The voltage is usually low, from 20 to 40 being ample in most cases, so that there is no possible chance of injury to the operator. The motor is usually supported in the stern of the boat by means of heavy braces, which are bolted to the body of the motor. This line of machines is manufactured by the Holtzer-Cabot Electric Company, of Boston, Mass.

Duro Blow-Off Valve.

Blow-off valves have given much trouble because the seat is so located that, as the disk approaches it, the accumulation of scale and sediment cuts into the face, wearing it off and blocking up the valve. The valve shown in the illustration is made by the Lunkenheimer Company, Cincinnati, Ohio, and embodies a simple but ingenious device for obviating this trouble, as it has a self-cleaning seat. There is a small steam inlet *A* which connects with an annular passage *C*. In the iron body of the valve is a brass casing *D*, with circular slot *J* cut into the side just below the level of the seat *E*. The casing is held in place by the ring *E* screwing over same, and both of these parts are easily removed. To close the valve the disk is screwed down in the usual manner, and the edge of the disk passing the lower edge of the casing *D* cuts off most of the flow of water, sediment, etc. The valve in the steam pipe leading to *A* should now be open, thus admitting steam to *C* and *D*, which blows off the surface of the seat *E*.



A NEW BLOW-OFF VALVE FOR BOILERS.

The disk is now closed, cutting off the flow of steam from inlet *A* as well as blow-off from the boiler. The valve in the pipe leading to *A* can be left open at all times, as the disk of the blow-off valve would keep this outlet closed. The disk is reversible, having two faces equally serviceable, and when the faces become worn they can be renewed by refilling with babbitt metal. The other parts may be renewed at slight cost. A plug is provided at *B*, opposite the inlet, so that, if desired, this can be taken off and a rod run through the blow-off pipe to clean it out.

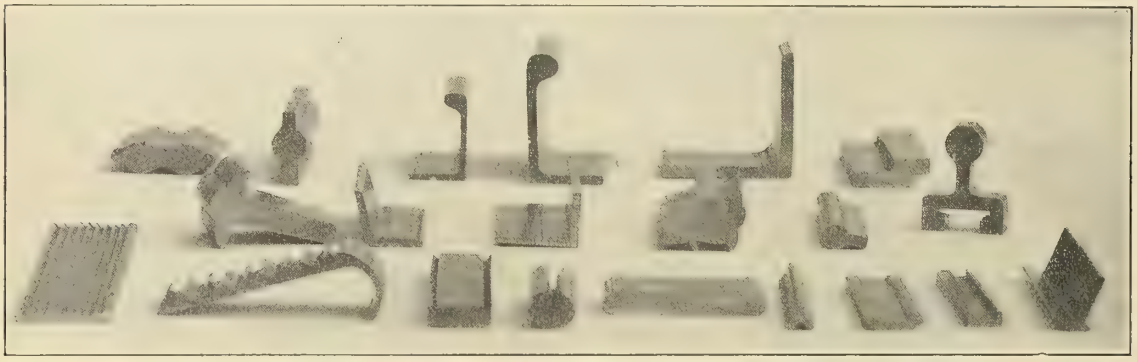
Brass or Bronze Bars Made by the Extrusion Process.

The Coe Brass Manufacturing Company, Ansonia, Conn., is now manufacturing bars of malleable brass, alloys, manganese bronze, Muntz metal, etc., by the extrusion process.

The process consists of forcing the heated metal by hydraulic pressure, frequently as high as 60,000 pounds per square inch, through a die of any desired shape. Owing to the great pressure put upon the semi-plastic metal, its molecules are densely compressed, and its quality must necessarily be greatly improved. Ex-

truded bars or rods consequently possess in a very marked degree those qualities which are essential for sound engineering work, and are free from those defects found in cast, rolled and drawn bars.

The dimensions of the bar being limited only by the area of its cross section, and the capacity of the container holding the charge of metal, extruded bars can be made ranging from light sections weighing a fraction of a pound per foot, to heavy round, square, hexagon or other section rods, more or less complicated, up to 40 pounds per foot. The light sections will run 50 to 60 feet in length, and the heavier angles from 30 to 40 feet.

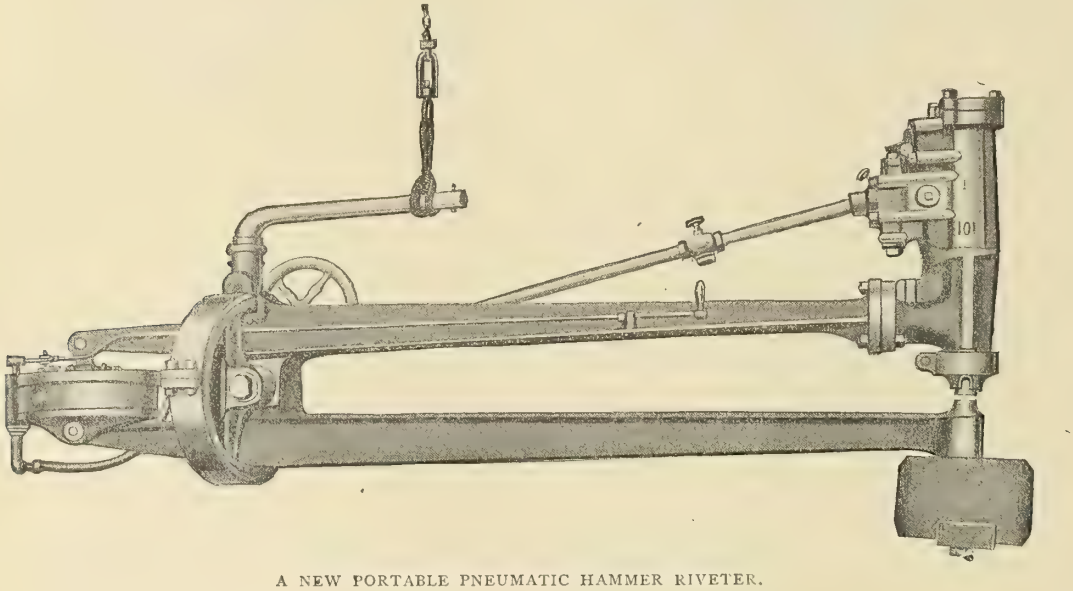


SAMPLES OF BARS OF BRASS AND BRONZE MADE BY THE EXTRUSION PROCESS.

As the dies are changed at every operation when a new charge of metal is put in, easy manipulation and rapid output are insured, so that orders for special sections can be supplied at very short notice after the dies are once made.

Outside of the vast number of commercial uses for these shaped sections, they can be utilized in the following instances: Plain angles, bulbs, T's, I beams, etc., for launches, yachts, torpedo boats and destroyers. This metal takes the places of steel frames, being practically equal in strength to mild steel, and where bronze outside plates are used, the length of time the boat could remain in commission without repairs or drydocking would be materially lengthened.

For forging, these bars can be upset to make spindles, bolts, nuts, screws, stays, etc. This material would enter into construction of general engineering and electrical work and equipment. One of the special qualities which makes this metal valuable for engineering purposes, lies in the fact that its strength is little reduced by high elevations of temperature. The crushing strength of the metal is enormous.



A NEW PORTABLE PNEUMATIC HAMMER RIVETER.

Portable Pneumatic Hammer Riveter.

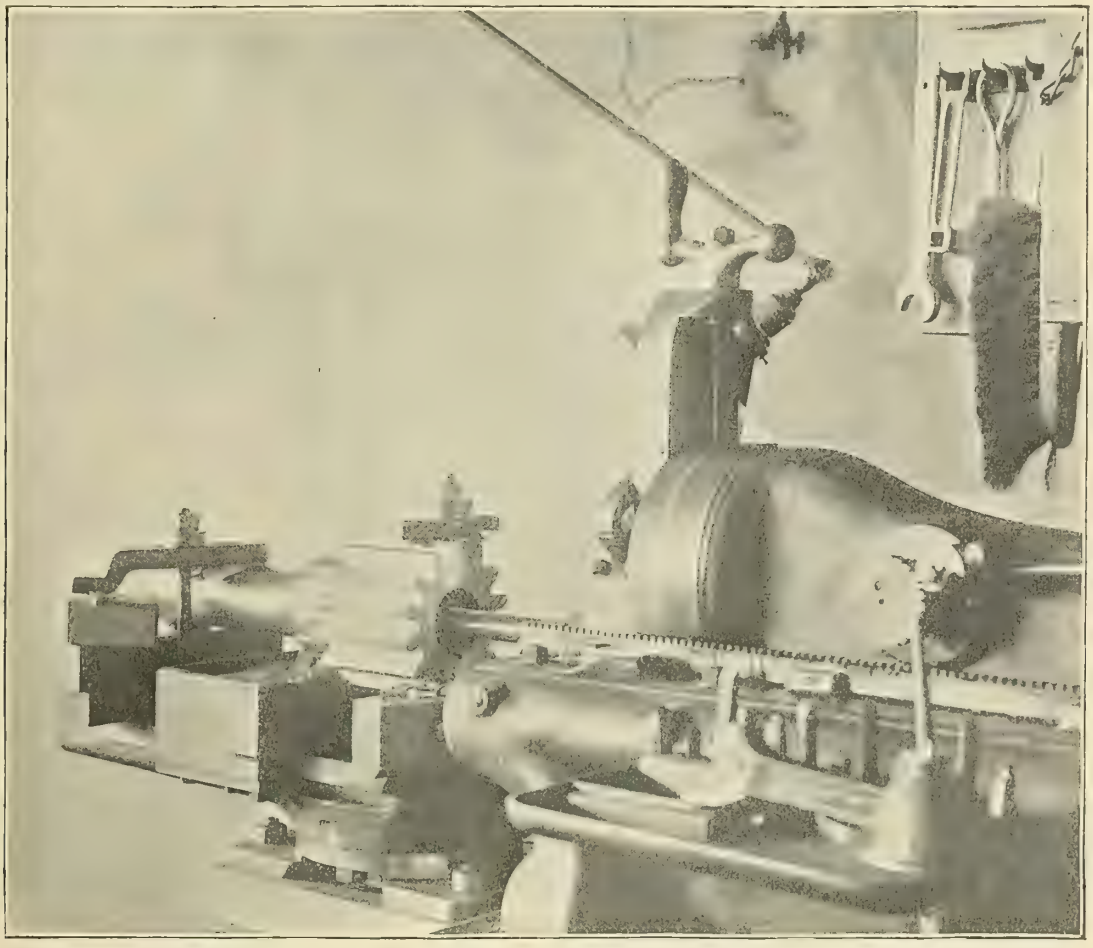
The illustration shown herewith is of a portable pneumatic hammer riveter for use on boiler and tank work, and made by John F. Allen, 370 Girard avenue, New York. It consists of two levers having at one end a pressure cylinder to open and close the levers, and at the other end the riveting machine on one arm and a suitable die with a counterweight attached on the other arm. These arms are of sufficient length so

that the riveter may be used upon circular seams of the boiler. The rivets are supported by a turning ring, which is operated by a worm wheel, thus enabling the machine to be placed at any desired angle to the boiler shell. The riveting machine consists of a cylinder with the hammer head or die attached to the end of the piston rod capable of being easily changed to adapt the machine for different sizes of rivets. The valve is operated directly by the pressure in the cylinder, and with an automatic regulation of the stroke to correspond with the gradual return of the end of the lever as the head is formed. The machine is suitably mounted on a traveling carriage, from which it may be applied to longitudinal seams of boiler shells.

Among the advantages claimed for this machine are that it makes tight work and drives as many rivets as the more expensive machines. A pressure of 3,000 pounds is applied to the plates to close them together before and during the time that the rivet is hammered. The riveter may also be used on small work, such as flues, and it is easily transferred from one part of the shop to the other.

A Handy Shaper.

In the accompanying cut is illustrated a difficult job, which was accomplished in an easy manner on one of the shapers made by Messrs. Gould and Eberhardt, Newark, N. J. It shows the adaptability of their machines to odd jobs as well as regular work. A steel driving pinion for the Holland submarine boat *Fulton* was to be keywayed. The pinion had a long hub and the hole through the hub was 1 1-8 inches in diameter while the hole in the pinion which was to be keywayed was 2 3-4 inches diameter. This would have been difficult to do properly on a keyseater, in which the cutting tool was actuated from below the table, as it would only be possible to use a long and slender bar, which would spring and make an unsatisfactory job.

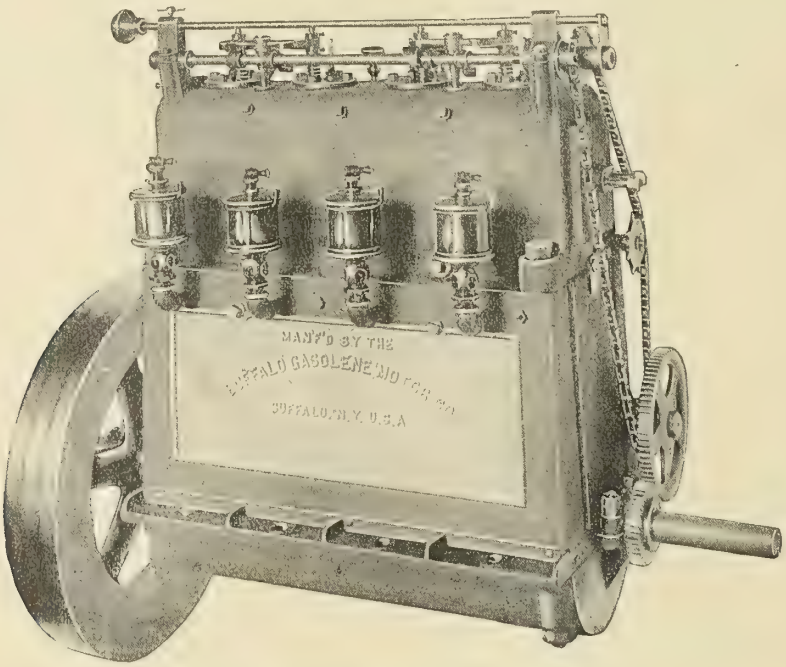


ILLUSTRATING THE USE OF A SHAPER IN PERFORMING A DIFFICULT OPERATION.

The pinion was clamped in the vise as shown, and to still further hold it, two bolts were employed, one on either side, at the front and back ends. The vise is provided with two T slots, one on each side of the screw, into which the heads of standard bolts were inserted, and the work tightened down by nuts and washers. A hole had been previously bored in the pinion to allow the chips to drop out at the finish of the cutting stroke. The cutter bar was held in a taper bush fitted to the hole in the flopper box used for tool post. The flopper box was held rigidly by gib screws, and this, together with the support given by the outer end of the cutter bar in the small hole in the hub insured a smooth, steady cut, and the job was finished in a comparatively short time.

Four Cylinder Gasolene Marine Motor.

A four-cylinder gasolene marine motor has been placed on the market by the Buffalo Gasolene Motor Company, Buffalo, N. Y., which embodies many good features and designs. This company manufactures both gas and gasolene motors of any size up to 80 horse power, for various classes of work. The standard type of motor, however, for either horizontal or vertical installation, is made in four sizes, namely: 4, 7 and 12 horse power. The accompanying illustration shows one of the 7 horse power vertical type of motors. The smallest size has two cylinders, and the two other sizes four cylinders. The 4 and 7 horse power may vary from 200 to 1,500 turns, and the largest size from 200 to 1,000 turns. A special feature is the ignition system by which this wide range of speed is possible. The ignition points are made of a special composition, and are riveted on, thus preventing them from burning or dropping off. Both the cylinders and heads, including the valves, are water jacketed, and all connections are made with double lock nuts and split keys. In the four-cylinder type, vibration is exceedingly small. The total weights of these three sizes are 255 pounds for the smallest, 315 for the 7 horse power and 475 pounds for the largest size. About one-fourth of the weight of the larger sizes is in the fly wheel. The directors of the Pan-American Exposition awarded this company the highest medal in this class. Further information may be had from the company, or from Charles E. Ingot, Humboldt street and Ingot avenue, Brooklyn, N. Y.



A FOUR CYLINDER MARINE GASOLENE ENGINE.

Repairs to Lake Steamers.—It is estimated that between seven and eight million dollars has been spent on repairing lake steamers during the present winter.

THE PROFESSOR ON SHIPBOARD.

Story of an Attempt to Combine Theory With Practice.

BY C. A. MCALLISTER, FIRST ASSISTANT ENGINEER, R.C.S.

CHAPTER VII.

When the Professor awoke from his refreshing slumber he found that the afternoon had nearly gone. The Captain announced to the passengers that they would, in all probability, sight land early the next morning, and that they would anchor in the harbor of St. Thomas, Danish West Indies, by eight o'clock. This was very cheering news to the Professor, and the prospects of lying in a smooth harbor where the ship would cease to roll for a time, not to mention the chance of stretching his legs on shore, proved very exhilarating. For the first time since he was overcome by the heat he sat down to the table, where he was congratulated upon his rapid recovery by a number of the passengers. Indeed, from the vivacity of his conversation, one could have well imagined that he had partaken of some very potent tonic to bring about such a change in his demeanor. With considerable glee he discussed the probability of the news that they would hear of the busy world since their departure from New York. He also made arrangements with several congenial persons to make a short sight-seeing trip on shore the next day. After dinner he resumed his seat on deck. He was soon joined by the Chief Engineer, who, after congratulating him on his improved appearance, told him that a number of the tubes had been found to be leaking so badly in the port forward boiler that he had been compelled to cut it out, and let the fires die down. He announced his intention of having the leaky tubes removed and new ones put in, after they got in port.

"As this will take us at least 48 hours, I will improve the opportunity and have the boiler given a thorough cleaning."

This statement led the Professor to inquire as to when the boiler was last cleaned. To this the Chief replied that the boiler in question had not been given a thorough cleaning in over a month. The visitor expressed considerable surprise at this remark, and said that he thought a boiler constantly under steam should be cleaned at least once in two weeks.

"That's all very well in theory," responded the Chief, "but you would find out, if you were running the steam machinery on a passenger ship, that you would not have the time to clean boilers so often. The owners want to keep the ship moving as rapidly as possible, and with the short crews they allow us in the engine department, we have to hustle to keep up even ordinary repairs and adjustments. If it were not for the fact that I have got to put in a lot of new tubes I wouldn't attempt to take the time for cleaning while we stop at St. Thomas."

The Professor argued that it would pay the vessel owners to take the time to have the boilers cleaned, claiming that the delay would be more than compensated for by the additional speed the vessel could make with clean boilers. He further added that if more care was exercised in the use of cylinder oil there would not be so much necessity for cleaning the interior of the boilers.

"It is not alone the cylinder oil that gives us trouble with the interior of our boilers," said the Chief; "we also have to contend with scale."

"I shouldn't think there would be much scale in your boilers, as you use an evaporator for the make-up feed supply." "Of course we do," said the Chief, "but you evidently forget that it is almost impossible to get a surface condenser perfectly tight, and as a result there is bound to be more or less leakage from the salt water ends to the steam side. In this way the salt water gets into the feed system and the result is that, in spite of the greatest care, a mixture of oil and scale is formed on the heating surfaces. You theoretical people imagine that because a condenser may be tight when it is first built, it will remain so for the rest of its existence."

"Oh, no, we don't," replied his brother, "but I did not imagine that the leakage in the condenser would have any appreciable effect on the formation of scale in the boilers." "Why," continued the Chief, "you have no idea of the different ways salt water does get into boilers sometimes. I have known cases where a vessel has been lying alongside of the wharf for a week or so, and the main condenser not being in use; yet in a few days I have discovered that the water in the boilers had become salted. This condition was no doubt largely due to carelessness on the part of the water tenders. For instance, when they use the auxiliary feed pump for pumping up the boilers they never took time to pump a few strokes overboard to get rid of any salt water that may have been in the pump cylinders and pipe connections. Another cause is that they neglect to close the sea suction valve tight on the manifold, and the result is that a small amount of salt water will be drawn in from that source; then, too, the sea suction valve may leak, in which case salt water will leak in, even if the valve is closed tightly. Why, I even caught one greenhorn who had been told to pump up the boiler from the fresh water tanks, with the bilge suction valve open, and there he was pumping bilge water in as feed water. You can bet that I put him on the dock in short order. It is all very well to wonder how salt water gets into boilers, but when you have had some of the experiences I have met with, your only surprise will be that more of it does not get in. If every man in the force worked like a machine, it would be all right, but on board ship you must watch everything closely or else you will get into all kinds of difficulties."

The Professor saw the force of his brother's arguments and had no more to say on that subject.

"I suppose you will renew the zincs in the boiler when you clean it out," remarked the Professor after a pause.

"Oh, yes," said the Chief, "we will put some new blocks in if they are necessary; but I don't take much stock in the use of zincs anyhow; they are said to be of great benefit, but I don't see that it makes much difference whether they are in there or not." "That is probably due to the fact that your zincs are not properly fitted," retorted the brother. "I am surprised to find how few people really understand the object of fitting zincs in a boiler, and the proper method of fitting them."

"Well, I must admit that I don't understand the exact theory of it myself," replied the Chief, "but perhaps you can enlighten me."

This gave the Professor an opportunity to expatiate on his ideas of the question, so he commenced thus:—

"The principal difficulty encountered in the care and preservation of the interior of marine boilers is to guard against corrosion and pitting. General corrosion uniformly distributed over the inner surfaces is not so bad, as with ordinary care, its effect, even after the boiler has been in use for several years, is hardly noticeable. 'Pitting' is quite a different problem to contend with, as it is generally manifested locally and at times its action is very quick. There are instances on record where new boilers have had to be re-tubed after being in service for only six months. Various theories have been advanced as to its cause, but it is now generally conceded that it is principally due to electro-chemical action. This action is on the same principle that electricity is generated in an ordinary electric battery, such as is used for ringing bells, etc. In such a battery, you know, a current is generated by the immersion of two metals or other substances of a different electrical potential, usually copper and zinc. The result of the continued submersion of these two metals in an acid liquid is the gradual disintegration of the zinc. A marine boiler containing water which has been allowed to become acid is in a manner an electric battery. With internal feed pipes, blow pipes, fittings, etc., of brass or copper, there is a tendency to start a flow of electricity between them and the steel of the boiler. The result is that certain portions of the steel or iron

becomes disintegrated and leaves small depressions or pits in the surfaces under the water. The copper is not alone responsible for galvanic action, as a current may be generated between different grades of iron or steel and even between the metal itself and the scale formed on its surface. When lap welded steel tubes first came into use, it was found that they corroded and pitted much more readily than charcoal iron tubes. Many persons attributed this condition to the fact that steel was more readily attacked by this pitting action than iron tubes. The fact of the matter was that to get steel to weld properly the tube manufacturers were compelled to use material cut from the tops of the ingots as they were cast; this, as you know, is very spongy metal, and the result was that the tubes proved very unreliable and eventually went out of use entirely. Since the advent of seamless drawn steel tubes it is found that they resist corrosion and pitting even better than charcoal iron tubes. Now to prevent this internal pitting the best plan is to keep the water from becoming acid. A galvanic battery will not work in absolutely pure water, and for that reason, as you may have noted, blue vitriol or sulphuric acid is put in the water of the cell. So it is with boilers, if the water is kept as nearly pure as possible, there is very little galvanic action. It is a very simple matter to test the water in a boiler; all you need to do is to draw out a glassful from one of the gauge cocks and drop in a small piece of litmus paper. If the water is acid the paper will turn red, but if it is alkaline the paper will retain its original color, blue. On naval vessels the engineers are required to make frequent tests of the water in the boilers for acidity. When it is ascertained that the water is in an acid condition steps should be taken to neutralize it by adding an alkaline solution, such as soda-ash. Zinc in the boilers also tends to neutralize the acidity, owing to the formation of zinc chloride during the decomposition of the metal. The principle use for the zinc is, however, to prevent the electro-chemical action, as it furnishes a material which is more electro positive to the copper, etc., than the iron or steel. Consequently the zinc is first attacked by the galvanic action.

"Now as to the method of putting the zinc in the boilers. From what I understand, the prevailing practice on board ship is to simply attach a clip to a slab of zinc and simply clamp it to the tubes or braces, without paying much attention to how it is secured. This is rather bad practice, for the zinc crumbles up and the detached particles get in the bottom of the boiler and are liable to stop up the blow valves. A much better practice is to place several slabs in a basket made of wrought iron or steel plates. The sides and ends of these baskets should be perforated so as to allow a free circulation of the water through them. The bottoms of the baskets should be left solid so as to catch the small particles of zinc as they become detached by the galvanic action. The most important thing to be considered is to have metallic contact between the zinc blocks and some parts of the boilers. That portion of the brace or tube to which the clamp for supporting the basket is to be secured should be filed bright, and the clamp should then be secured tight. It is also a good idea to cover the joint between the clamp and brace with putty or cement to keep the water from rusting the joint. The handle to the basket should be riveted to the sides, and if possible there should be an iron bolt passing through the sides of the basket and through each block of the zinc. Just here it may be well to call your attention to the fact that the blocks should be separated from each other. If they are put in so that they touch each other, it will be found that the blocks will swell and naturally burst the basket.

"Rolled zinc is said to be better for this purpose than cast zinc. However they are placed, the greatest care must be exercised to secure and maintain the metallic connection, as otherwise the zinc will be of very little use. Care should also be taken to distribute the zincs in such a manner that all of the inner parts of the boiler are uniformly protected."

The Chief had been listening attentively to what his brother had to say in regard to zincs, and at the conclusion of his remarks said, "I had no idea that it was so important to fit these zinc blocks so carefully, and after this I will give that matter more attention."

The Professor looked at his watch, and finding that it was getting rather late in the evening, told his brother that as he still felt somewhat weak and fatigued, he would retire, so as to get up early in the morning and be ready to go ashore.

At six o'clock the following morning the Professor was called, and as he got up and looked out of his stateroom window he was much elated to see that land was plainly visible straight ahead. After dressing he went out on deck and found that most of the passengers had also risen early and were gathered in groups on the upper deck gazing wistfully at the green hills in the distance. Good humor prevailed and the Professor secretly wished that the land in sight was the coast of New Jersey and that they were about to enter New York harbor. All hands ate an early breakfast and began making preparations to go on shore. Shortly after eight o'clock the anchor was dropped and the ship was safely moored in the harbor.

The Professor looked into the engine room door, and stood there in meditation for a few moments. The men on watch had already begun to wipe down the engine and clean up around the engine room. The college man could not help but compare the engine with a thoroughbred horse which had just finished a hard run and was being groomed by the attendants. But how different the work performed by the animal and by this creation of man! Ever since the vessel had left New York over a week before, the faithful engine had kept steadily at work hour after hour, day after day, never tiring, but keeping up a continuous turning of the propeller. He also made mental comparisons between the performance of a marine engine and that of locomotives and stationary engines. After a run of a few hours a locomotive is taken to the shelter of a round house and groomed for another run on the following day. Stationary engines run during working hours and are usually shut

down half the time; but the sturdy marine engine must keep going day after day for periods often as long as fifteen or twenty days at a stretch, without ever stopping. The safety of the ship and the lives of the passengers and crew depend upon its faithful performance of duty. Surely, throught the Professor, man has created no more wonderful mechanism than the marine engine. Too much care and attention cannot be exercised in their construction, nor too much credit given to the men who successfully operate them at sea. While thus absorbed in thought, Barney approached him unobserved and somewhat startled the Professor by saying:—

"Well, sor, you look as plased as if you had just got a letter from home with money in it."

"I feel somewhat that way, Barney," replied the college man.

Just then one of the sailors came up and told him that the boat was ready to take the passengers ashore. The Professor got out his sun umbrella and climbed into the boat with a party of the passengers. Soon they were at the landing and as they stepped out, the usually sedate looking college man had the appearance of a colt let loose in a pasture. If he had known how, it is within the bounds of possibility that he might have attempted a cake walk.

The party of passengers wandered about the town, visited the fort, called on the American consul, purchased curios, took a drive out in the suburbs and in the evening took dinner at one of the leading hotels. After dinner they sat out in the park listening to the music of a very good military band. The tropical air was scented by the numerous flowers in the park, and as the evening was cool, the party enjoyed their brief respite on shore to the utmost. When it came time to return on board ship, the Professor and one or two others made up their minds to stop at the hotel over night. The Professor had never before realized what a luxury it is to stretch out in a large roomy bed, and he concluded that a sailor's life is not a happy one, when compared with that of any ordinary citizen on shore.

QUERIES AND ANSWERS.

Q.—Will you please advise me regarding the following:—

On the bridge of our steam yacht, within two (2) feet of our compass, is an electric searchlight. It appears to effect the compass to the extent of a point or more.

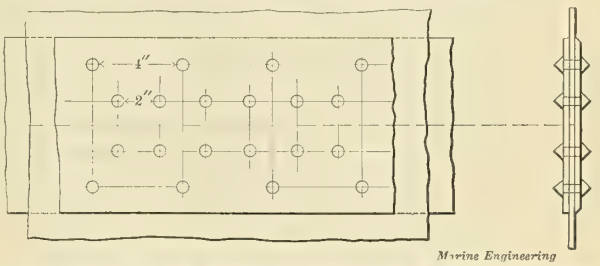
Kindly let me know whether it is probable that it is effected as above, and if so, how far apart it will be necessary to have the compass and the searchlight to overcome same. Will five (5) feet be sufficient? The compass is Sir William Thompson's make, and is very sensitive. S. S. E.

A.—The extent to which an electric searchlight would affect your compass will depend largely on the details of the construction of the light, and especially on the number and strength of regulating magnets which may be employed. It is very sure, however, that with the usual type of light at a distance of only two feet, any good compass would be affected, and especially one of the type mentioned. The average extent to which a light affects the card can be determind by making careful observations on various courses with the light on and off, and this is by all means the best way of finding a suitable distance to which the light should be removed. With many forms of light five feet would still be too near, but with a small yacht light it may be found to be a sufficient distance. Probably, however, eight or ten feet would be better. The only satisfactory way will be to try by experiment until a distance is found at which there is no sensible disturbance due to the operation of the light.

Q.—Please let me know through your valuable paper, the percentage of strength of the following boiler seam:—

Sheets 1-2 inch thick, 60,000 pounds, T. S., boiler 10 feet in diameter, butt joint, strap in and outside, same thickness as shell, 5-8 inch rivets pitched, 2-inch and 4-inch.

What I want to know is how much strength these straps add to the sheet and how this is found.



Marine Engineering

A.—We must first compare the strength in the plate and in the rivets. To do this we find the two efficiencies for the rivets and for the plate. Assuming that the rows of rivets are properly spaced and that rupture can be held to the outer row of rivets, then the joint efficiency so far as the plate is concerned, is (4—11-16) ÷ 4 = .83 nearly.

To find the efficiency of the rivets we must adopt some figure for the relative strength of a rivet in double shear and in single shear, and some figure for the relative strength of a rivet in shear and for the plate in tension. You have taken the rivet in double shear as having twice the strength in single shear. This is more than is usually allowed. The British Board of Trade authorizes the ratio 1 3-4. You have, however, taken the shearing strength as 2-3 the strength in tension. This is perhaps rather low. Taking .7 for this ratio we should then have for the rivet efficiency the following expression: (3 × 7-4 × .3712 × .7) ÷ (4 × 1-2), which equals .685. On this basis, therefore, the joint is weaker in the rivets than in the plate. If we should use the proportion authorized by the British Board of Trade, which is .821, we should find in the same way an efficiency of .805, showing still that the rivets are weaker than the plate.

Regarding the pressure allowed, figuring by the United States rule and adding 20 per cent for double riveting, as the rule allows, we find 100 pounds. Using the British Board of Trade rule with a joint efficiency of .805 we should find 88 pounds as the allowed pressure. By Lloyd's rule the efficiency of the joint becomes .83, and using their rule for pressure in the form usually employed, the allowed pressure on a 10-foot boiler with double butt straps, is found to be 83 pounds.

Regarding the effect of the double butt straps, the efficiency and strength for a single butt strap or for a plain lap joint should be figured as follows:—

There are two rivets in single shear and the joint efficiency in the rivets, allowing a shearing strength .821 the tensile strength, is given by the expression:—

$$(3 \times .3712 \div .821) + (4 \times 1\text{-}2) = .46$$

The plate efficiency must now be taken along the inner row of rivets, since there would be nothing to prevent rupture along this row. This would give for the plate efficiency:—

$$(2 - 11\text{-}16) \div 2 = .66$$

The given distribution of rivets is not of course the best for a plain lap joint, but with a more suitable distribution a better efficiency could be realized. With the distribution as given, however, these figures show that the addition of the second strap results in raising the figures for efficiency from these very low values to the higher values given above.

Q.—How is the tonnage of steam vessels rated? That is, is the number of cubic feet cargo carrying capacity reckoned on in figuring the tonnage, or is it the entire displacement of vessel, displacing a corresponding volume of water?

Supposing a vessel rated 3,000 tons gross and used as a freight boat was altered on her deck and between decks and changed into a passenger steamer, thus losing the considerable amount of space which otherwise would be utilized for cargo. Would this decrease the gross tonnage of vessel as rated by United States steamboat inspectors, and if so, to what extent would this loss of cubic feet cargo capacity affect the tonnage of the vessel? L. S. R.

A.—The necessary space required prevents a full statement of the rules for measuring tonnage. They will be found in the Navigation Laws of the United States, Revised Statutes, Title XLVIII., Chapter I, sections 4,150, 4,151, 4,152, 4,153, 4,154 and also Chapter 398.

We may briefly explain, however, that the tonnage of a vessel is intended to relate to the carrying capacity of the ship, and is based upon the internal volume, and not upon the displacement. The gross tonnage represents in a general way the total internal volume of the ship below the so-called tonnage deck. From this total volume the volumes of various spaces are subtracted, thus giving the net tonnage. These spaces deducted include in a general way the spaces or compartments occupied by or appropriated to the use of the crew of the vessel, but this deduction must not exceed five per cent of the gross tonnage.

Again, in every vessel propelled by steam or other power requiring an engine room, the volume of the space or spaces actually occupied by or required for the proper working of the boilers and machinery, and in the case of vessels propelled by screw plus 75 per cent of the volume of such space, is also subtracted. Again, in no case shall this subtraction exceed 50 per cent of the gross tonnage.

If the changes to which you refer in the vessel rated at 3,000 tons gross, were such as to leave the crew space and machinery space the same, then there seems to be no reason for assuming a change in net tonnage. It would be well, however, in regard to the details of government practice in these matters to consult with your nearest local inspector.

Q.—Will you explain how the formula $D^2 \times .7854$ for the area of a circle is found? All the hand books have it, but none of them explain why.

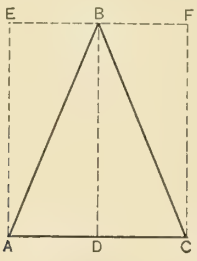


FIG 1.

A.—You know perhaps that the area of a triangle such as *ABC* is found by multiplying the base *AC* by the altitude *BD* and taking one-half the product. If this is not clear you can readily see that the triangle *ABC* is made up of two triangles *ABD* and *BCD*. Now, taking the first it is clear that the triangle *ABD* is equal to the triangle *AEB*, and therefore that each of them is half of the rectangle *AEBD*. In the same way the triangle *DBC* is the half of the rectangle *DBFC*. Hence the whole triangle *ABC* is also the half of the rectangle *AEFC*. But the area of the rectangle *AEFC* equals the product of the base by the altitude, or *AC* x *BD*. Hence the area of the triangle, or half of this will equal half the product of the base by the altitude. Now, to turn to the circle, suppose that it is divided up into a very large number of triangles, as indicated in the figure. Then the area of any one of the little triangles, as *OAB*, will be one-half the product of the base *AB* by the altitude *OP*. Now, if we should make the number of triangles larger and larger and the length of the base, as *AB*, smaller and smaller, then the altitude *OP* would become more and more nearly the same as the radius of the circle or side of the triangle *OA*. Finally, when the triangles get down in our imagination almost too narrow to think of, we can imagine that the difference between *OA* and the altitude *OP* will become too small to be of any importance. Also at the same time the base of the triangle *AB* will become so nearly a part of the arc of the circle that the difference will be of no importance, and in the same way the area of the triangle will become so near to the area of the corresponding part of the circle that the difference will be of no importance.

The sum of the areas of all the little triangles would then be so near to the area of the circle that the error would be of no importance. Now, since each one of them is measured by one-half the product of the base by the altitude, it follows that the sum of them all will be measured by one-half the product of the sum of the bases by the altitude. But the sum of the bases as we have seen, is the circumference, or so near to it that the difference is of no importance, while the altitude is the radius *OA*, or so near to it that the difference is of no importance. Hence, the area of the circle is measured by one-half the product of the circumference by the radius, or at least so far as we have been able to see, the difference between this and the true value will be of no importance.

Mathematicians are able to tell us that when we imagine the little triangles carried on down to absolutely the farthest limit, when they become indefinitely large in number and indefinitely small in size, then the altitude becomes really the radius, and the sum of the bases becomes really the circumference, while also the sum of the areas becomes really the area of the circle without any difference from the true value in either case. Hence we may consider that for finding the area of a circle we have the rule, "Take half the product of the circumference by the radius." Now, if we put this in algebraic form we shall have:—

$$A = 1/2\,CR$$

where C stands for circumference and R for radius. Now, if we put D for diameter we shall have $D=2\,R$, or $R=1\text{-}2\,D$ Putting this into the equation above we shall have $A = 1\text{-}2\,C \times 1\text{-}2\,D$ or $1\text{-}4\,CD$. Now, again, mathematicians are able to tell us just what the relation is between C and D, the circumference and diameter of a circle. This number is often denoted by the Greek letter π called *pi*, and the value usually employed is 3.1416. Hence we shall have $C = 3.1416\,D$. Putting this for C in the value of the area above and we have $A = 1\text{-}4 \times 3.1416 \times D \times D$.

Dividing 3.1416 by 4 we find .7854, and multiplying $D \times D$ we have D^2. Hence we find at the end of our operation:—

$A = .7854\,D^2$ the formula you asked about at the beginning.

Q. We have a vertical triple expansion engine, with cylinders 15 1-2 inches, 26 inches and 42 inches by 22-inch stroke.

With valve gear linked up so as to cut off, as in the following table, steam at 155 pounds, intermediate receiver 45 pounds, low pressure 0 and vacuum 23 inches, we get these results:—

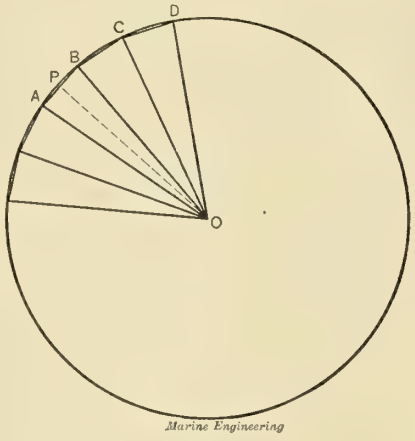


FIG 2.

	Cut off.	Lead.	Lap.	I. H. P.
H. P.	10 1-2 inches	1-16 inch	1 9-16 inches	187
I. P.	11 3-4 inches	1-16 inch	2 7-16 inches	225
L. P.	13 inches	3-16 inch	2 19-32 inches	123

With the engine in full gear the points of cut off are, high pressure, 13 5-8 inches; intermediate pressure, 13 5-8 inches; low pressure, 14 7-16 inches.

We are putting in new boilers to carry 180 pounds of steam, and wish to change valve gear so as to equalize the high pressure in each engine when running full gear. Can we, by changing the valve gear, equalize the power, and if so, how can it be done? The valve gear is of the Joy type. H. H. A.

A. The equalization of power in the cylinders of a triple expansion engine is brought about by changing the cut off in the intermediate and low pressure cylinders. Making the cut off later in either of these cylinders will decrease the power in that particular cylinder, and making it earlier will increase the power. If the distribution of power in full gear is therefore similar to that linked up, and as given in your letter, it would indicate that the intermediate cut off should be made later, and the low pressure cut off earlier. How much this should be changed can only be found by actual trial. It is to provide for the possibility of such an adjustment of cut off that valve gears often contain an adjustable piece, so arranged that each cut off may be varied independently of the others, and an adjustment for equalizing the power thus effected. Such an adjustment is often met with in the Stephenson link gear, in the

form of a block moving in a slot formed in the rock shaft arm, and controlled by a screw. In the Joy gear such an arrangement is less commonly found, but it might easily be fitted. It requires simply some means of varying the connection between the rock shaft arms and the reversing radius, so that each radius may be adjusted independently of the others. Then, with the high pressure cylinder in full gear, the other cut offs should be adjusted until by the indicator a satisfactory distribution of power is brought about.

Q.—What is the average cost per indicated horse power of the best type of modern steamships, using high pressure and triple expansion engines? Also, the coal consumption per hour per indicated horse power, and would the consumption vary per indicated horse power in the case of a 2,000-ton vessel with two triple expansion engines and one triple expansion engine? Also, would the proportion vary in a 10,000-ton vessel? That is, would the economy of a 10,000-ton vessel using one triple expansion engine and consuming steam with this one unit be more economical than by using two units; and the same in regard to the 2,000-ton vessel?

Can you inform me if there is any paper or book published which enters into the statistics of the running costs of single or twin screw modern steamers?

L. S. R.

A.—We suppose that you mean by the first part of your question the cost of propelling machinery per indicated horse power. There is no relation whatever between the cost of the ship and the indicated horse power. The cost of propelling machinery per indicated horse power varies through wide limits of course, depending on the grade of work and other circumstances. From $20 to $40 per indicated horse power will, however, cover the usual range of prices.

The coal consumption per hour per indicated horse power in modern practice varies from 1.5 pounds to perhaps 1.8 pounds. Where especial attention to economy has been paid this figure may be reduced below 1.5, and there are records of performances as low as 1 pound per indicated horse power per hour. With the large units named there is no necessary relation between the economy of the engine and the size, and there is no reason why there should be any sensible difference in the economy of two triple expansion engines or one of the same total power. In a general way we might expect a slightly better economy for the larger engine, and therefore for the 10,000-ton vessel, but this is so slight as to be easily lost or obscured by slight differences in the conditions of operation.

We are not aware of any paper or book giving statistics of the running costs of single or twin screw modern steamers.

Q. What is the proper way of connecting a motor starter with the motor? Should it be connected so as to have the resistance in the armature circuit or in the main circuit? Please let me know which is the proper way, and why.

B. M. G.

A. The proper way to connect a motor starter is with the resistance in the armature circuit only. The resistance of the armature is very low, and if the motor is of any size above half a horse power the current that would pass through the armature in the act of starting would be very strong, if no resistance were used. As soon as the armature begins to revolve it sets up a back pressure that prevents the current flowing through it so freely. The object of the resistance is to keep the current strength down while the speed is building up. If the resistance is placed in the armature circuit only the full voltage acts upon the field coils, and thus the field is magnetized to its full strength from the very start. If the resistance were placed in the main circuit it would cut down the current through the field coils just as much as that through the armature, and the result would be that the field magnets would be so weak that the torque, or rotating force of the armature, would be too small to set it in motion unless running free. From this it will be seen that the placing of the starter resistance in the armature circuit not only acts to keep down the strength of the armature current in starting, but at the same time causes the full strength of field current to flow through the field coils and thus enables the armature to start off with a very strong torque; stronger, in fact, than it gives when running at full speed.

Early Ship Building.— The first ship built in this country is claimed to have been constructed on the banks of the Kennebec river in 1607. A party of colonists under the direction of Capt. George Popham landed on the Kennebec from the ships *Gift of God* and *Mary* and started a settlement and the following year built the ship *Virginia* of 130 tons.

Floating Dock for Odessa.—A floating drydock was recently built at Fuime, Hungary, for the Russian Steam Navigation and Trading Company, of Odessa, and has been safely towed to its point of destination. It is built in two parts, one part being divided into four pontoons and the other part into three pontoons, with a total lifting power of 4,800 tons. The dock is valued at about $403,000.

Transatlantic Freight. — The transatlantic steamship freight agreement went into effect on January 21st. The pool is the largest ever formed, and includes the White Star and Cunard lines, New York and Liverpool; Atlantic Transport Line, to Liverpool from New York, Philadelphia and Baltimore; National Line, New York and Liverpool; Leyland Line, from New York, Boston and New Orleans to Liverpool, and from Boston to London; the Wilson and the Phoenix Line, New York and Hull; Wilson-Furness and Leyland Line, Boston and London; Lamport and Holt Line, New York and Manchester; the American and Red Star Lines, New York and Southampton, Philadelphia to Liverpool and Southampton; The Philadelphia and Manchester Line, Chesapeake and Ohio Steamship Company, Newport News to London and Liverpool; Virginia Line, Norfolk to Liverpool and London, and the Dominion Line, from Boston to Liverpool. The new rates apply to three commodities only—grain, flour and provisions—and are only for outgoing freights shipped to England.

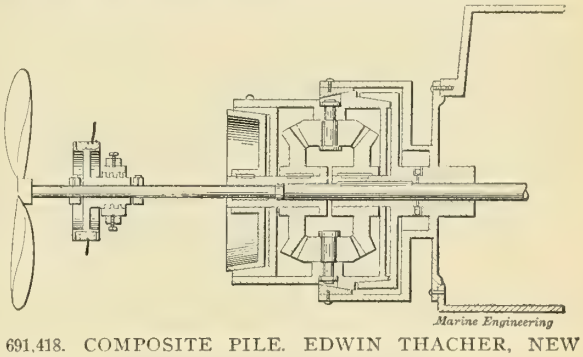
SELECTED MARINE PATENTS.

690,961. MANUFACTURE OR TREATMENT OF ARMOR-PLATES. BENTON K. JAMISON, PHILADELPHIA, PA.

691,254. MEANS FOR POSITIONING AND FIRING HEAVY ORDNANCE. THEODORE M. FOOTE, BROOKLYN, N. Y., assignor to Edwin H. Brown, borough of Manhattan, New York, N. Y.

691,258. SCREW-PROPELLED BOAT. HERMAN T. GAY, BALTIMORE, MD.

691,300. REVERSING APPARATUS FOR PROPELLER SHAFTS. JOHN TITUS, TOWNSEND W. BURT AND DANIEL D. SMITH, OYSTER BAY, N. Y., assignors to the Oyster Bay Engine Company, a corporation of New York.



Marine Engineering

691,418. COMPOSITE PILE. EDWIN THACHER, NEW YORK, N. Y.

Claim.—1. A composite pile having an upper portion of concrete, in which are imbedded a plurality of longitudinal metallic bars, a lower portion of wood, and means for splicing the two parts togethers. Three claims.

691,451. APPARATUS FOR INDICATING, RECORDING AND INTREGRATING THE SPEED OF VESSELS. CHARLES E. DELANOY, NEW YORK, N. Y., assignor to Delanoy Safety Log Company, a corporation of New York.

Claim.—1. In an apparatus for ascertaining the speed of vessels by the tension produced by a log, the combination of a lever-arm, a spring against which it acts, a line or cable for ap-

plying the tension to said lever-arm indicating mechanism connected to said lever-arm to indicate the rate of speed, and a means for reducing the movement or displacement of the indicating mechanism to correspond substantially to the square root of the applied tension. Four claims.

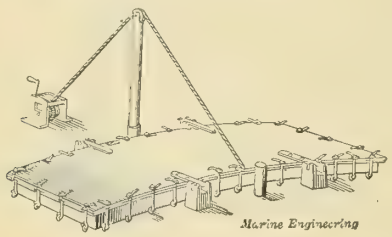
691,514. PROPELLER. WILLIAM O. WHITNEY, GLENS FALLS, N. Y.

Claim.—1. A propeller consisting of a hub and blades, each of which has the form of a cone section, the adjacent edges of said blades being secured to the face of the hub along spiral lines. Seven claims.

691,713. APPARATUS FOR RAISING SUNKEN SHIPS. MATIEU BOURHANOVSKY, LIBAU, and ALEXANDRE DE KOWANKO, ST. PETERSBURG, RUSSIA.

Claim.—1. In an apparatus for raising sunken objects, an inflatable receptacle provided with suitable inlet and outlets, tubes depending into said receptacle from said outlets, means for adjusting said tubes, a supporting cover mounted upon the receptacle, and means connected with the supporting cover for attaching the apparatus to the object to be raised. Nine claims.

691,752. HATCH-COVER. WINFIELD W. DAWLEY, GENEVA, OHIO.

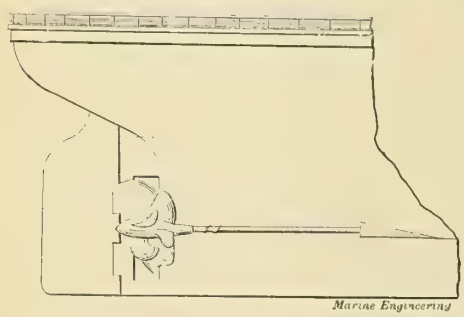


Claim.—1. The combination with a decked vessel having a hatch and a hatch-coaming therefor, of a hatch-cover extending over and beyond the hatch-coaming, angle-irons fastened to the under side of the cover and having outwardly extending horizontal members lying snugly gainst the cover, and vertical members extending downward inside of the hatch-coaming, a packing-gasket secured to the under side of the horizontal member of the angle-iron, and bearing on the hatch-coaming, transversely-projecting arms fastened to the hatch-cover and extending beyond the same and provided at their ends with trunnions, and stanchions fastened to the deck, and having bearings therein for the reception of the trunnions. One claim.

691,792. SCREW-PROPELLER. FRANK C. METZ, ALLEGHENY, PA.

692,001. APPARATUS FOR RAISING SUNKEN VESSELS. JOHN BARKER, SEATTLE, WASH.

692,117. MARINE PROPULSION. ISAAC M. CHASE, WASHINGTON, D. C.



Claim.—1. A screw-propeller, in combination with fixed guide-blades aft of, surrounding, extending forward and terminating at approximately the longitudinal center of the screw.

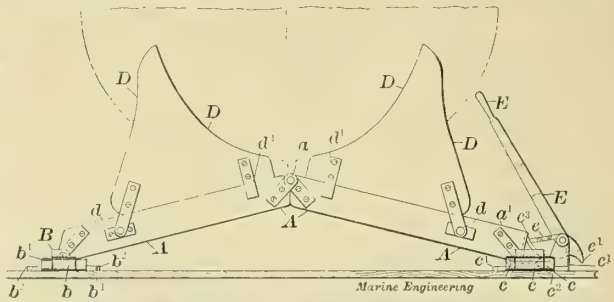
2. A screw-propeller, in combination with fixed guide-blades aft of the screw, and having a pitch and a curve from the root to the tip of the blade approximately the pitch and curve of the screw. Eight claims.

692,355. APPARATUS FOR LOADING OR UNLOADING BULK CARGOES. ALEXANDER W. ROBERTSON, LONDON, ENGLAND.

Claim.—1. The combination with a pontoon of a movable carriage secured thereto, means for securing a floating vessel to said carriage, and means for transferring the bulk cargoes of said floating vessel, as set forth. Fifteen claims.

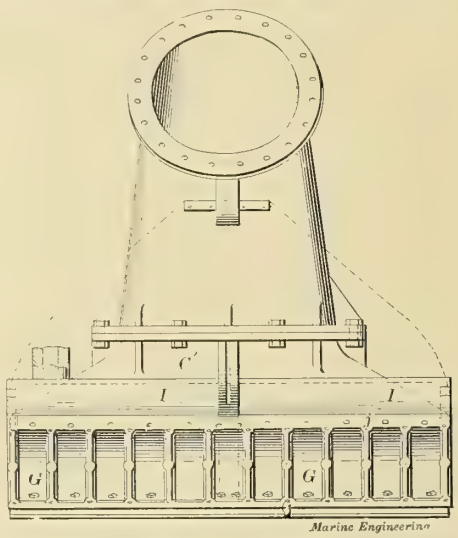
692,400. MEANS FOR DISENGAGING AND REPLACING THE SUPPORTS OF BOATS ON SHIPS, ETC. THOMAS WILSON, SUNDERLAND, ENGLAND.

Claim.—1. Means for disengaging and replacing the supports of boats on ships and elsewhere, comprising bars or supports A, A carrying chocks D, D, hinged together endwise so as to be angled or distended, and capable of being tilted or turned over to one side, and a lever E upon the deck or other place for effecting or controlling said movements, substantially as described and shown.



2. Means for disengaging and replacing the supports of boats on ships and elsewhere comprising bars or supports A A, a bracket B pivoted to the deck or other support and having a pivotal connection with one of the said bars, and a guide-bracket C similarly pivoted to the deck or support, the other end of the other bar or support A being mounted in said guide-bracket C, whereby the arms or supports, when distended, can be tilted over to one side free from the boat, substantially as described. Seven claims.

692,815. MOUTH-PIECE FOR SUCTION DREDGES. LINDON W. BATES, CHICAGO, ILL.



Claim.—1. A mouthpiece for trailers of suction-dredges provided with a cutting edge; and a series of water-jets located in a plane above said cutting edge, and arranged to act in conjunction therewith, said jets being directed outwardly in substantially parallel lines, with said edge away from the mouthpiece. Six claims.

692,910. PROPELLER FOR VESSELS. DETLEF H. ROHWEDDER, CHICAGO, ILL.

692,973. HYDRAULIC DREDGE. LINDON W. BATES, CHICAGO, ILL.

Claim.—1. In combination with the discharge pipe of a dredge, a baffle-plate adapted to receive the impact or pressure of the outflowing current from said pipe, said baffle-plate having two diverging faces, and being greater in depth at its extremities than at the point of junction of said faces. Five claims.

693,228. BOAT ADAPTED TO BE PROPELLED ON LAND OR IN WATER. SAMUEL T. BRITTAIN, BOSTON, MASS.

693,242. APPARATUS FOR CLEANING BOTTOMS OF SHIPS. ROBERT S. CULPEPPER, HOUSTON, TEXAS, assignor of two-thirds to Abnus B. Kerr and Ira M. Bryce, Houston, Texas.

Claim.—1. A cleaning device for ships' sides and bottoms, having a jet-nozzle opening in opposite direction to the operating face of the cleaning device to hold the latter up to its work, and means for moving the cleaning device over the ship's surface substantially as described.

2. A cleaning device for ships' sides and bottoms, consisting of two separate brushes. Four claims.

693,272. AUTOMATIC DRIVING MECHANISM FOR SUBMARINE BOATS. JOHN P. HOLLAND, NEWARK, N. J.